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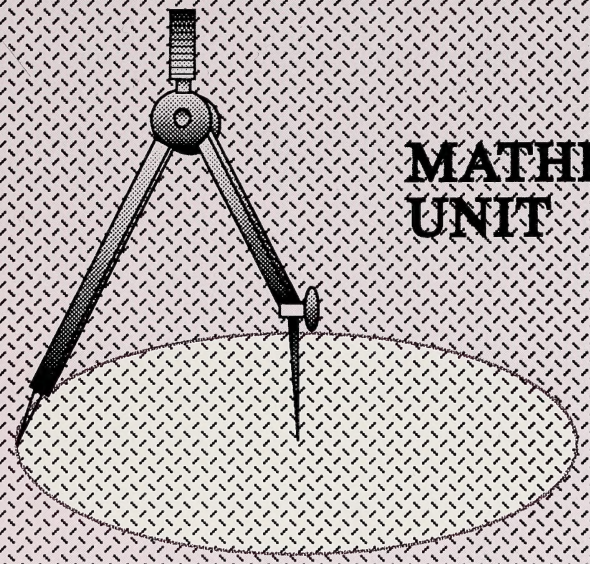
MATHEMATICS 23



MATHEMATICS OF FINANCE
UNIT 3

Distance Learning

Alberta
EDUCATION

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Welcome

Distance Learning

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General Information

This information explains the basic layout of each booklet.

- **What You Already Know** and **Review** are to help you look back at what you have previously studied. The questions are to jog your memory and to prepare you for the learning that is going to happen in this unit.
- As you begin each **Topic**, spend a little time looking over the components. Doing this will give you a preview of what will be covered in the topic and will set your mind in the direction of learning.
- **Exploring the Topic** includes the objectives, concept development, and activities for each objective. Use your own papers to arrive at the answers in the activities.
- **Extra Help** reviews the topic. If you had any difficulty with **Exploring the Topic**, you may find this part helpful.
- **Extensions** gives you the opportunity to take the topic one step further.
- To summarize what you have learned, and to find instructions on doing the unit assignment, turn to the **Unit Summary** at the end of the unit.
- The **Appendices** include the solutions to **Activities (Appendix A)** and any other charts, tables, etc. which may be referred to in the topics **(Appendix B, etc.)**.

Visual Cues

Visual cues are pictures that are used to identify important areas of the material. They are found throughout the booklet.

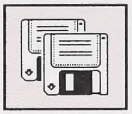
An explanation of what they mean is written beside each visual cue.

Key Idea
- flagging important ideas

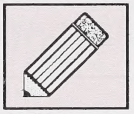
Audiotape
- learning by listening to an audiotape

What You Already Know
- reviewing what you already know

Another View
- exploring different perspectives



Computer Software
- learning by using computer software



Review
- studying previous concepts

Solutions
- correcting the activities

Videotape
- learning by viewing a videotape

Introduction
- introducing the unit

Extra Help
- providing additional study

Print Pathway
- choosing a print alternative

What Lies Ahead
- previewing the unit

Extensions
- going on with the topic

Calculator
- using your calculator

Exploring the Topic
- actively learning new concepts

What You Have Learned
- summarizing what you have learned

Mathematics 23

Course Overview

Mathematics 23 contains 8 units. Beside each unit is a percentage that indicates what the unit is worth in relation to the rest of the course. The units and their percentages are listed below. You will be studying the unit that is shaded.

Unit 1 Powers and Radicals	10%
Unit 2 Algebra	12%
Unit 3 **Mathematics of Finance**	**4%**
Unit 4 Linear Relations	12%
Unit 5 Systems of Equations	16%
Unit 6 Geometry	16%
Unit 7 Trigonometry	16%
Unit 8 Statistics	14%
	100%

Unit Assessment

After completing the unit you will be given a mark based totally on a unit assignment. This assignment will be found in the Assignment Booklet.

Unit Assignment - 100%

If you are working on a CML terminal your teacher will determine what this assessment will be. It may be

Unit assignment - 50%
Supervised unit test - 50%

Introduction to Mathematics of Finance

This unit covers a topic dealing with Mathematics of Finance. Each topic contains explanations, examples, and activities to assist you in understanding mathematics of finance. If you find you are having difficulty with the explanations and the way the material is presented, there is a section called **Extra Help.** If you would like to extend your knowledge of the topic, there is a section called **Extensions.**

You can evaluate your understanding of each topic by working through the activities. Answers are found in the Solutions in **Appendix A.** In several cases there is more than one way to do the question.

Unit 3 Mathematics of Finance

Contents at a Glance

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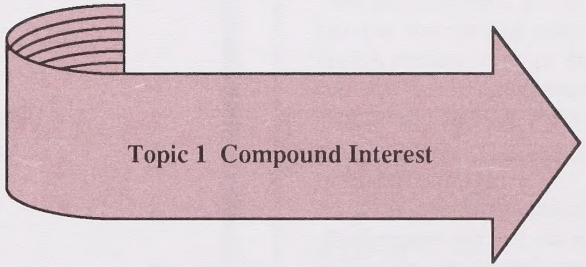
Mathematics of Finance

In our society, people often borrow money to purchase a variety of goods and services. People also invest money in term deposits, Canada Savings Bonds, Guaranteed Investment Certificates, and savings accounts at the local bank. In all cases, money, in the form of interest, must be paid on borrowed or invested funds.

In this unit, you will learn to calculate the amount of interest owed or earned using various formulas. You will review the simple interest formula, develop a formula for compound interest, and use this formula to solve practical problems.

Unit 3

Mathematics of Finance



What You Already Know

Refresh your memory!

1. Recall the following terms.

   - Per annum means per year.
   - Annually means once a year.
   - Semiannually means twice a year.
   - Quarterly means four times a year.

2. To convert days and months into parts of a year, you must write the number as a fraction with either 12 months or 365 days as the denominator.

   8 months: $\frac{8}{12} = \frac{2}{3}$ year

   80 days: $\frac{80}{365} = \frac{16}{73}$ year

3. To convert percentages to decimals, divide the percentage value by 100.

   $12\% = \frac{12}{100}$

   $= 0.12$ in decimal form.

   $4\frac{1}{2}\% = \frac{4\frac{1}{2}}{100} = \frac{4.5}{100}$

   $= 0.045$ in decimal form.

   $8\frac{1}{4}\% = \frac{8\frac{1}{4}}{100} = \frac{8.25}{100}$

   $= 0.0825$ in decimal form.

4. A power such as $(1.6)^3$ has a base of 1.6 and an exponent of 3. The exponent indicates the number of times the base is to be used as a factor when evaluating the power.

   $(1.6)^3 = 1.6 \times 1.6 \times 1.6 = 4.096$

5. You can use a scientific calculator to evaluate the power $(1.6)^3$.

Enter	Display
C	0
1.6	1.6
x^y	1.6
3	3
=	4.096

Depending on the type of calculator you own, the power key is either y^x or x^y.

All fractions should be expressed in simplest form.

6. Recall the formula used to compute simple interest.

$I = P \times r \times t$

I = simple **interest** (in dollars)
P = **principal** (the original dollar amount that is earning interest)
r = annual interest **rate** (a percentage converted to decimal form)
t = **time** (expressed in years)

7. Recall how to solve problems using the simple interest formula.

Example 1

Dale Carter deposited $1500.00 in a savings account that pays interest at a rate of 6% per annum. Calculate the amount of simple interest that he earned after 5 months.

Solution:

Use the simple interest formula $I = P \times r \times t$.

In this case, $I = ?$ $P = \$1500.00$

$r = 6\%$ $t = 5$ months

$= \frac{6}{100}$ $= \frac{5}{12}$ years

$= 0.06$

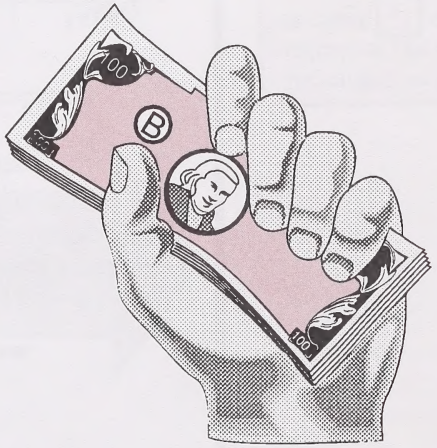
Now place these values into the formula.

$$I = \$1500 \times 0.06 \times \frac{5}{12}$$

$$= 90 \times \frac{5}{12}$$

$$= \$37.50$$

Dale earned $37.50 interest on the $1500.00 in his savings account.



Now that you have examined the material that you studied previously, go to the **Review** to confirm your understanding of this material.

Review

Try the following review questions.

1. Convert the days and months to parts of a year. (Be sure to express all answers in simplest form.)

   a. 15 months

   b. 225 days

   c. 22 months

   d. 146 days

2. Convert the percents to decimal form.

   a. $6\frac{3}{4}\%$ b. 9%

   c. $13\frac{1}{2}\%$ d. $4\frac{1}{4}\%$

3. Use your calculator to find the value of each of the following.

   a. $(2.75)^4$ b. $(8.9)^2$

   c. $(1.025)^6$ d. $(4.35)^{12}$

4. Determine the amount of simple interest given the following.

   a. $P = \$20\,000.00$ $r = 9\frac{1}{2}\%$ $t = 2$ years

   b. $P = \$4000.00$ $r = 5\%$ $t = 99$ days

5. Arlene borrowed $2200.00 from her local bank and agreed to pay interest at a rate of $14\frac{1}{4}\%$ per annum. Calculate the amount of simple interest that Arlene would owe after 1 month.

Now go to the **Review** solutions in **Appendix A.**

If you have difficulty with these questions, proceed to Mathematics 9, Module 4 for a review of simple interest.

Topic 1 Compound Interest

Introduction

Can you calculate the amount of interest charged on the unpaid balance of your credit card account? How much interest would you receive per year on $5000, if the interest is paid at a rate of 13% compounded semiannually?

The answers to these questions require an understanding of compound interest.

What Lies Ahead

Throughout the topic you will learn to

1. use repeated simple interest calculations to determine the amount of compound interest
2. use the compound interest formula $A = P(1+i)^n$ and a calculator to calculate compound interest
3. calculate compound interest using compound interest tables

Now that you know what to expect, turn the page to begin your study of compound interest.

Exploring Topic 1

Activity 1

Use repeated simple interest calculations to determine the amount of compound interest.

Allison Hughes has recently purchased $1000 worth of Canada Savings Bonds. The bonds will earn Allison interest at a rate of $10\frac{1}{2}\%$ per year compounded annually. How much will the bonds be worth after three years?

Use the simple interest formula to calculate the amount of interest that Allison will receive.

$I = ?$ $P = \$1000$ $r = 10\frac{1}{2}\%/\text{a}$ $t = 3$ years

$I = \$1000 \times 0.105 \times 3$
$= \$315.00$

Using the simple interest formula, you would expect Allison to receive $315.00 in interest when cashing in the $1000.00 worth of Canada Savings Bonds after three years.

This calculation is wrong! Allison will actually receive more than $315.00 in interest, due to the magic of compound interest.

Compound interest is interest earned not only on the original amount, but also on the interest earned during previous interest periods.

Recalculate the interest on Allison's Canada Savings Bonds, adding the interest earned each year to the principal.

End of first year

$I = Prt$ $I = ?$ $P = \$1000.00$
$r = 10\frac{1}{2}\%$ per year $t = 1$ year

$I = \$1000 \times 0.105 \times 1$
$= \$105.00$

Allison earned $105.00 in interest after the first year.

The interest rate is usually expressed as per annum or per year unless otherwise stated.

If the rate is expressed as $10\frac{1}{2}\%/\text{a}$, this means $10\frac{1}{2}\%$ per annum or per year.

Remember, $\frac{10.5}{100} = 0.105$ in decimal form.

End of second year

$I = Prt \quad I = ? \quad P = (\$1000 + \$105)$
$= \$1105.00$

$r = 10\frac{1}{2}\%/\text{a}$
$t = 1$ year

$I = \$1105.00 \times 0.105 \times 1$
$= \$116.025$
$= \$116.03$ (rounded to the nearest cent)

Allison earned \$116.03 in interest after the second year.

End of third year

$I = Prt \quad I = ? \quad P = (\$1105 + \$116.03)$
$= (\$1221.03)$

$r = 10\frac{1}{2}\%$
$t = 1$ year

$I = \$1221.03 \times 0.105 \times 1$
$= \$128.208\ 15$
$= \$128.21$ (rounded to the nearest cent)

Allison earned \$128.21 interest in the third year.

After three years, the total amount of interest earned would be
\$105 + \$116.03 + \$128.21 = \$349.24.

Allison earned \$349.24 in interest on her \$1000 Canada Savings Bond.

That is \$34.24 more than predicted using the simple interest formula!

Try another problem dealing with compound interest.

Example 1

Ryan McGowan borrowed \$4000.00 from his local bank at a rate of 14%/a, compounded semiannually for a two-year term, to buy a used car.

- How much interest will Ryan have to pay in two years?

Solution:

Calculate the simple interest for every six months by using $I = P \times r \times t$.

These calculations are done in the table at the top of the next page. Use this table to calculate the total interest in the next step.

Ryan will owe the bank \$1243.18 in interest after two years.
\$280 + \$299.60 + \$320.57 + \$343.01 = \$1243.18

- Find the total cost of the car.

Solution:

After two years, Ryan will have to pay back both the principal and interest.
\$4000 + \$1243.18 = \$5243.18

The total cost of the car would be \$5243.18.

The principal in the second year is equal to the original principal (\$1000) plus the interest earned in the first year (\$105).

Interest compounded semiannually is calculated every 6 months or $\frac{1}{2}$ year.

Semiannually (6 month terms)	Principal plus Previous Interest	Simple Interest per Term Use $I = P \times r \times t$
1st	\$4000	$I = \$4000 \times 0.14 \times \frac{1}{2} = \$280$
2nd	\$4000 + \$280 = \$4280	$I = \$4280 \times 0.14 \times \frac{1}{2} = \$299.60$
3rd	\$4280 + \$299.60 = \$4579.60	$I = \$4579.60 \times 0.14 \times \frac{1}{2} = \$320.57$
4th	\$4579.60 + \$320.57 = \$4900.17	$I = \$4900.17 \times 0.14 \times \frac{1}{2} = \$343.01$

Now that you are interested, complete the following questions.

1. Find the compound interest for the first two compounding periods by using the simple interest formula.

   a. $P = \$650$ $r = 8\frac{1}{2}\%$/a compounded semiannually

   b. $P = \$2500$ $r = 16\%$/a compounded quarterly

   c. $P = \$1400$ $r = 12\frac{1}{2}\%$/a compounded monthly

2. Martin Singh invested \$3700.00 in a term deposit which pays $11\frac{1}{4}\%$/a compounded quarterly for fifteen months. Find the total amount of interest Martin will receive after fifteen months.

3. Betty Lane received a cash advance of \$650 using her credit card. The terms of the credit card indicate that Betty will have to pay 21%/a interest compounded monthly. How much will Betty pay in interest charges if she repays the money three months later?

For solutions to **Activity 1**, turn to **Appendix A, Topic 1.**

Activity 2

Use the compound interest formula $A = P(1+i)^n$ and a calculator to calculate compound interest.

You are probably thinking that there must be an easier way to calculate the amount of compound interest when you were performing all the simple interest calculations. Try to develop a formula to simplify the calculation of compound interest.

Sandi deposited $800.00 into a savings account that pays interest at 10% per annum compounded monthly. Find the total amount of money in her account after six months.

The amount of money in Sandi's savings account at the end of each month will be the total of the principal, plus the interest earned for the month.

Amount = principal + interest

These calculations will have to be made six times to find the total amount in Sandi's savings account after six months.

Your calculations can be done in two ways.

- When calculating the amount $[A = P + (P \times r \times t)]$, the rate r is the rate per annum and the time t is the length of the compounding period (in years).

  $A = ?\quad I = ?$
  $P = \$800\quad r = 10\%\quad t = \frac{1}{12}$ year

  $A = \$800 + (\$800 \times 0.10 \times \frac{1}{12})$

  $A = \$800 + \$6.67$

  $A = \$806.67$ (after the first month)

- The amount could also be calculated by using the rate per compounding period and a time period of one year.

  $A = ?\quad I = ?$
  $P = 800\quad r = \dfrac{10\%}{12 \text{ months}}\quad t = 1$ period
  $= 0.8333\%$

  $A = \$800 + (\$800 \times 0.008\,333 \times 1)$

  $= \$800 + \$6.67$

  $= \$806.67$ (after the first month)

$$0.8333\% = \frac{0.8333}{100} = 0.008\,333$$

The calculations for Sandi's $800.00 savings account are shown on the chart below.

Period	Principal	Calculation $P + (Prt)$	Amount
1st	$800.00	$\$800 + (\$800 \times 0.008\ 333 \times 1)$	$806.67
2nd	$806.67	$\$806.67 + (\$806.67 \times 0.008\ 333 \times 1)$	$813.39
3rd	$813.39	$\$813.39 + (\$813.39 \times 0.008\ 333 \times 1)$	$820.17
4th	$820.17	$\$820.17 + (\$820.17 \times 0.008\ 333 \times 1)$	$827.00
5th	$827.00	$\$827.00 + (\$827.00 \times 0.008\ 333 \times 1)$	$833.89
6th	$833.89	$\$833.89 + (\$833.89 \times 0.008\ 333 \times 1)$	$840.84

Sandi would have $840.84 in her savings account after six months.

Is there a pattern in the calculations that could be used to develop a compound interest formula?

Yes! Notice that the compounding period (1) and the interest rate per period (0.008 333) remain constant. Only the principal increases as the number of compounding periods increase.

Examine the formula $A = P + P \times r \times t$.

You could simplify this formula by factoring out the principal P from both terms.

$$A = P + P \times r \times t$$

$$A = P\ (1 + 1 \times r \times t)$$

To calculate the amount in Sandi's savings account you would let $r = 0.008\ 333$ and $t = 1$.

$$A = P\ (1 + 1 \times 0.008\ 333 \times 1)$$

$$A = P\ (1 + 0.008\ 333)$$

$$A = P\ (1.008\ 333)$$

Knowing the principal for any period, you could use this formula to find the amount in Sandi's savings account after the first compounding period.

Find the amount for the third compounding period, where $P = \$813.39$ (from the chart of repeated simple interest calculations).

$$A = P\ (1.008\ 333)$$

$$A = \$813.39\ (1.008\ 333)$$

$$= \$820.17 \text{ (rounded to the nearest cent)}$$

This amount is the same as we calculated using the repeated simple interest calculations.

Suppose you do not want to go through the repeated simple interest calculations to find the amount for each compounding period. What would happen if you used the original principal and multiplied it by 1.008 333 three times, once for each compounding period? Will you still get an amount equal to \$820.17?

Try it.

$$A = \$800\ (1.008\ 333)\ (1.008\ 333)\ (1.008\ 333)$$
$$= \$820.17$$

It works! The amount is the same as you derived using simple interest calculations.

The formula could also have been written as

$$A = \$800(1.008\ 333)^3,$$

where the exponent 3 represents the number of compounding periods.

Check the validity of this formula by finding the amount in Sandi's savings account after six months.

$$A = \$800(1.008\ 333)^6$$

When factoring out P, divide each term by P.

$$A = P\left(\frac{\overset{1}{\cancel{P}}}{\underset{1}{\cancel{P}}} + \frac{\overset{1}{\cancel{P}} \times r \times t}{\underset{1}{\cancel{P}}}\right)$$

$$A = P\left(\frac{1}{1} + \frac{1 \times rt}{1}\right)$$

$$A = P(1 + 1 \times rt)$$

In six months, there would be six compounding periods.

You can use your calculator to solve for A by following these steps.

Enter	Display
C	0
1.008333	1.008333
x^y	1.008333
6	6
×	1.051051229
800	800
=	840.8409828

The display should read 840.8409828, which equals $840.84 (rounded to the nearest cent).

This is exactly the same answer as you derived using repeated simple interest calculations. (Refer back to the chart.)

This means that you can calculate the amount, given the rate of compound interest, using the formula

$$A = P(1+r)^n$$

or

$$A = P(1+i)^n,$$

where A = amount in dollars
P = the principal
i = interest rate per compounding period (in decimal form)
n = number of compounding periods.

When given a problem, you can find the values for i and n using the following.

$$i = \frac{\text{annual interest rate}}{\text{number of interest periods in a year}}$$

n = number of interest periods per year × number of years

You should now be able to solve for i and n.

Most texts use i to represent the interest rate.

1. Complete the following table.

Annual Rate of Interest	Compounding Period	Number of Years	Number of Compounding Periods (n)	Rate per Compounding Period (i)
10%	semiannually	6		
13%	annually	8		
9%	monthly	5		
8%	quarterly	7		
5%	daily	2		
$7\frac{1}{2}\%$	monthly	3		
12%	semiannually	4		

For solutions to **Activity 2**, turn to **Appendix A, Topic 1.**

Now, put the compound interest formula to work.

Example 2

George Dickens borrowed $8500 from Metro Trust to purchase a new car. Find the amount needed to repay the loan at the end of four years if interest at 16% per annum is compounded semiannually.

Solution:

Use the compound interest formula $A = P(1+i)^n$, where A = ? and P = $8500.00.

$$i = \frac{\text{rate per annum}}{\text{number of interest periods in a year}}$$

$$= \frac{16\%}{2}$$

$$= \frac{0.16}{2}$$

$$= 0.08$$

$$\text{and } n = \begin{pmatrix}\text{number of periods}\\ \text{per annum}\end{pmatrix} \times \begin{pmatrix}\text{number of}\\ \text{years}\end{pmatrix}$$

$$n = \quad 2 \quad \times \quad 4$$

$$n = 8$$

$$A = \$8500(1+0.08)^8$$

$$= \$8500(1.08)^8$$

$$= \$8500(1.850\,930\,21)$$

$$A = \$15\,732.906\,79$$

$$= \$15\,732.91 \text{(rounded to the nearest cent)}$$

George would need $15 732.91 to repay the loan at the end of four years. (Note: George did not make any monthly payments on this loan. He paid the whole amount after four years.)

Try the following questions on your own.

2. Kelly Conner wants to borrow $6000 for two years to start a small business.

   a. Calculate the amount that Kelly would owe at the end of two years given the following interest rates.

      i. 14% per annum compounded monthly

      ii. 14% per annum compounded semiannually

      iii. 14% per annum compounded quarterly

      iv. 14% per annum compounded annually

   b. Which is the best rate?

3. Eldon wants to invest money in a five-year term deposit. To determine the amount in Eldon's term deposit after five years, the banker uses the following formula.

   $A = 3200(1+0.03)^{20}$

   Determine each of the following amounts.

   a. the principal

   b. the compounding period

   c. the interest rate per annum

   d. the amount in Eldon's term deposit after five years

4. Maria opened a savings account at her local bank, depositing $620.00. The interest rate on the account is 9% per annum compounded daily. Calculate the amount in Maria's account after the following periods of time.

   a. 90 days b. 230 days

5. Jill Wing wants to invest $1400 in Guaranteed Investment Certificates which pay interest at a rate of 11%, compounded semiannually. Complete the following chart to determine how long it will take Jill's investment to double to $2800.

Principal (P)	Interest Rate per Compounding Period (i)	Number of Compounding Periods (n)	Amount $A = P(1+i)^n$
$1400	0.055	6	
$1400	0.055	8	
$1400	0.055	10	
$1400	0.055	12	
$1400	0.055	13	
$1400	0.055	14	

For solutions to **Activity 2**, turn to **Appendix A, Topic 1.**

Activity 3

Calculate compound interest using compound interest tables.

Tracy Ronning has invested $4500 in Canada Savings Bonds which are paying 9% per annum compounded semiannually. Tracy wants to cash in the bonds after three years and use the money as a down payment for a new car.

Tracy knows that she can use the compound interest formula $A = P(1+i)^n$ to determine the amount that she will receive after three years. The following values would be inserted into the compound interest formula.

$A = ?$ $P = \$4500$ $i = \frac{9\%}{2}$ $n = 2 \times 3$ years

$= \frac{0.09}{2}$ $= 6$

$= 0.045$

Tracy would have to solve the formula $A = \$4500(1+0.045)^6$.

The calculations would be easy with a scientific calculator, but Tracy's calculator does not have the power key x^y.

Could Tracy still calculate the amount using the compound interest formula?

It takes more work, but Tracy knows that $(1.045)^6$ is the same as $1.045 \times 1.045 \times 1.045 \times 1.045 \times 1.045 \times 1.045$.

After multiplying, Tracy found that $(1.045)^6 = 1.302\,260\,125$. This number is then multiplied by the principal amount ($4500).

$A = \$4500\ (1.302\ 260\ 125)$
$= \$5860.17$

Tracy will receive $5860.17 for her $4500 Canada Savings Bonds after three years.

Tracy's method worked well in this case, but what if the number of compounding periods *(n)* increased? These calculations could become long if *n* were 12, 16, 20, or any large value.

To simplify these calculations, mathematicians developed tables consisting of values for $(1+i)^n$ with various values for *i* and *n*.

The compound interest table consists of a number of columns, each containing a series of values for a certain interest rate per period. The values in each column change as the number of periods *(n)* increase.

The **amount** is the total of the principal + interest.

Study the following table.

Interest Tables $(1 + i)^n$ Compound Amount of 1

n	3.5%	4%	4.5%	5%	5.5%	6%	6.5%	7%	7.5%	8%
1	1.035 000	1.040 000	1.045 000	1.050 000	1.055 000	1.060 000	1.065 000	1.070 000	1.075 000	1.080 000
2	1.071 225	1.081 600	1.092 025	1.102 500	1.113 025	1.123 600	1.134 225	1.144 900	1.155 625	1.166 400
3	1.108 718	1.124 864	1.141 166	1.157 625	1.174 241	1.191 016	1.207 950	1.225 043	1.242 297	1.259 712
4	1.147 523	1.169 859	1.192 519	1.215 506	1.238 825	1.262 477	1.286 466	1.310 796	1.335 469	1.360 489
5	1.187 686	1.216 653	1.246 182	1.276 282	1.306 960	1.338 226	1.370 087	1.402 552	1.435 629	1.469 328
6	1.229 255	1.265 319	1.302 260	1.340 096	1.378 843	1.418 519	1.459 142	1.500 730	1.543 302	1.586 874
7	1.272 279	1.315 932	1.360 862	1.407 100	1.454 679	1.503 630	1.553 987	1.605 781	1.659 049	1.713 824
8	1.316 809	1.368 569	1.422 101	1.477 455	1.534 687	1.593 848	1.654 996	1.718 186	1.783 478	1.850 930
9	1.362 897	1.423 312	1.486 095	1.551 328	1.619 094	1.689 479	1.762 570	1.838 459	1.917 239	1.999 005
10	1.410 599	1.480 244	1.552 969	1.628 895	1.708 144	1.790 848	1.877 137	1.967 151	2.061 032	2.158 925
11	1.459 970	1.539 454	1.622 853	1.710 339	1.802 092	1.898 299	1.999 151	2.104 852	2.215 609	2.331 639
12	1.511 069	1.601 032	1.695 881	1.795 856	1.901 207	2.012 196	2.129 096	2.252 192	2.381 780	2.518 170
13	1.563 956	1.665 074	1.772 196	1.885 649	2.005 774	2.132 928	2.267 487	2.409 845	2.560 413	2.719 624
14	1.618 695	1.731 676	1.851 945	1.979 932	2.116 091	2.260 904	2.414 874	2.578 534	2.752 444	2.937 194
15	1.675 349	1.800 944	1.935 282	2.078 928	2.232 476	2.396 558	2.571 841	2.759 032	2.958 877	3.172 169
16	1.733 986	1.872 981	2.022 370	2.182 875	2.355 263	2.540 352	2.739 011	2.952 164	3.180 793	3.425 943
17	1.794 676	1.947 900	2.113 377	2.292 018	2.484 802	2.692 773	2.917 046	3.158 815	3.419 353	3.700 018
18	1.857 489	2.025 817	2.208 479	2.406 619	2.621 466	2.854 339	3.106 654	3.379 932	3.675 804	3.996 019
19	1.922 501	2.106 849	2.307 860	2.526 950	2.765 647	3.025 600	3.308 587	3.616 528	3.951 489	4.315 701
20	1.989 789	2.191 123	2.411 714	2.653 298	2.917 757	3.207 135	3.523 645	3.869 684	4.247 851	4.660 957
21	2.059 431	2.278 768	2.520 241	2.785 963	3.078 234	3.399 564	3.752 682	4.410 562	4.566 440	5.033 834
22	2.131 512	2.369 919	2.633 652	2.925 261	3.247 537	3.603 537	3.996 606	4.430 402	4.908 923	5.436 540
23	2.206 114	2.464 716	2.752 166	3.071 524	3.426 152	3.819 750	4.256 386	4.740 530	5.277 092	5.871 464
24	2.283 328	2.563 304	2.876 014	3.225 100	3.614 590	4.048 935	4.533 051	5.072 367	5.672 874	6.341 181
25	2.363 245	2.665 836	3.005 434	3.386 355	3.813 392	4.291 871	4.827 699	5.427 433	6.098 340	6.848 475

The values in the table represent the compound amount on one dollar for each compounding period. To calculate the amount that $500 would accrue to, you would have to multiply the value from the table by 500. (Accrue means to "build up to.")

Use the compound interest table to calculate the value of Tracy's Canada Savings Bonds after three years.

Step 1: Find the interest rate per compounding period (i) and the number of periods (n) .

$$i = \frac{9\%}{2}$$
$$= 4.5\% \text{ per compounding period}$$
$$n = 2 \times 3 \text{ years}$$
$$= 6$$

Step 2: Read the value from the table where the 4.5% column is intersected by the row where n is equal to 6. What is the value you should obtain?

Interest Tables $(1 + i)^n$ Compound Amount of 1

n	3.5%	4%	4.5%	5%	5.5%	6%	6.5%	7%	7.5%	8%
1	1.035 000	1.040 000	1.045 000	1.050 000	1.055 000	1.060 000	1.065 000	1.070 000	1.075 000	1.080 000
2	1.071 225	1.081 600	1.092 025	1.102 500	1.113 025	1.123 600	1.134 225	1.144 900	1.155 625	1.166 400
3	1.108 718	1.124 864	1.141 166	1.157 625	1.174 241	1.191 016	1.207 950	1.225 043	1.242 297	1.259 712
4	1.147 523	1.169 859	1.192 519	1.215 506	1.238 825	1.262 477	1.286 466	1.310 796	1.335 469	1.360 489
5	1.187 686	1.216 653	1.246 182	1.276 282	1.306 960	1.338 226	1.370 087	1.402 552	1.435 629	1.469 328
6	1.229 255	1.265 319	1.302 260	1.340 096	1.378 843	1.418 519	1.459 142	1.500 730	1.543 302	1.586 874
7	1.272 279	1.315 932	1.360 862	1.407 100	1.454 679	1.503 630	1.553 987	1.605 781	1.659 049	1.713 824
8	1.316 809	1.368 569	1.422 101	1.477 455	1.534 687	1.593 848	1.654 996	1.718 186	1.783 478	1.850 930
9	1.362 897	1.423 312	1.486 095	1.551 328	1.619 094	1.689 479	1.762 570	1.838 459	1.917 239	1.999 005
10	1.410 599	1.480 244	1.552 969	1.628 895	1.708 144	1.790 848	1.877 137	1.967 151	2.061 032	2.158 925
11	1.459 970	1.539 454	1.622 853	1.710 339	1.802 092	1.898 299	1.999 151	2.104 852	2.215 609	2.331 639
12	1.511 069	1.601 032	1.695 881	1.795 856	1.901 207	2.012 196	2.129 096	2.252 192	2.381 780	2.518 170
13	1.563 956	1.665 074	1.772 196	1.885 649	2.005 774	2.132 928	2.267 487	2.409 845	2.560 413	2.719 624
14	1.618 695	1.731 676	1.851 945	1.979 932	2.116 091	2.260 904	2.414 874	2.578 534	2.752 444	2.937 194
15	1.675 349	1.800 944	1.935 282	2.078 928	2.232 476	2.396 558	2.571 841	2.759 032	2.958 877	3.172 169

Step 3: Multiply the value you obtained in Step 2 by the principal of Tracy's Canada Savings Bonds ($4500).

$$A = P(1+i)^n$$
$$= \$4500(1.302\,260)$$
$$= \$5860.17$$

Tracy's bonds would be worth $5860.17 after three years, the same amount that you calculated with the previous method.

Complete interest tables can be found in **Appendix B.**

Try another question using the compound interest tables.

Example 3

Bonnie Aber wants to borrow $950 to purchase a new set of stereo speakers. The Longarm Credit Union has agreed to lend Bonnie the $950 at a rate of 12% per annum compounded quarterly. Find the amount of interest that Bonnie would pay if she repaid the loan eighteen months later.

Solution:

Find the amount of compound interest Bonnie must pay using the formula $A = P(1+i)^n$.

The amount (A) is a total of the principal (P) plus the interest. Thus, subtracting the principal from the total amount to be repaid equals the amount of interest. Note: Interest compounded quarterly is compounded every three months.

$A = ?$ $P = \$950$ $i = \dfrac{12\%}{4}$

$$= \frac{0.12}{4}$$
$$= 0.03 \text{ or } 3\%$$

$$n = \frac{18 \text{ months}}{3 \text{ months}}$$
$$= 6 \text{ compounding periods}$$

You can now use the compound interest tables to find the value for $(1+i)^n$ with $i = 0.03$ or 3% and $n = 6$.

Compound Interest

n	0.25%	0.5%	0.75%	1%	1.25%	1.5%	1.75%	2%	2.5%	3%
1	1.002 500	1.005 000	1.007 500	1.010 000	1.012 500	1.015 000	1.017 500	1.020 000	1.025 000	1.030 000
2	1.005 006	1.010 025	1.015 056	1.020 100	1.025 156	1.030 225	1.035 306	1.040 400	1.050 625	1.060 900
3	1.007 519	1.015 075	1.022 669	1.030 301	1.037 971	1.045 678	1.053 424	1.061 208	1.076 891	1.092 727
4	1.010 038	1.020 151	1.030 339	1.040 604	1.050 945	1.061 364	1.071 859	1.082 432	1.103 813	1.125 509
5	1.012 563	1.025 251	1.038 067	1.051 010	1.064 082	1.077 284	1.090 617	1.104 081	1.131 408	1.159 274
6	1.015 094	1.030 378	1.045 852	1.061 520	1.077 383	1.093 443	1.109 702	1.126 162	1.159 693	1.194 052
7	1.017 632	1.035 529	1.053 696	1.072 135	1.090 850	1.109 845	1.129 122	1.148 686	1.188 686	1.229 874
8	1.020 176	1.040 707	1.061 599	1.082 857	1.104 486	1.126 493	1.148 882	1.171 659	1.218 403	1.266 770
9	1.022 726	1.045 911	1.069 561	1.093 685	1.118 292	1.143 390	1.168 987	1.195 093	1.248 863	1.304 773
10	1.025 283	1.051 140	1.077 583	1.104 622	1.132 271	1.160 541	1.189 444	1.218 994	1.280 085	1.343 916
11	1.027 846	1.056 396	1.085 664	1.115 668	1.146 424	1.177 949	1.210 260	1.243 374	1.312 087	1.384 234
12	1.030 416	1.061 678	1.093 807	1.126 825	1.160 755	1.195 618	1.231 439	1.268 242	1.344 889	1.425 761
13	1.032 992	1.066 986	1.102 101	1.138 093	1.175 264	1.213 552	1.252 990	1.293 607	1.378 511	1.468 534
14	1.035 574	1.072 321	1.110 276	1.149 474	1.189 955	1.231 756	1.274 917	1.319 479	1.412 974	1.512 590
15	1.038 163	1.077 683	1.118 603	1.160 969	1.204 829	1.250 232	1.297 228	1.345 868	1.448 298	1.557 967

The value from the table is 1.194 052. This value is then multiplied by the principal to give the amount to be repaid (A).

$A = \$950(1.194\,052)$

$= \$1134.35$

Bonnie would have to repay the Longarm Credit Union \$1134.35. The amount of interest Bonnie paid over 18 months would be \$1134.35 – \$950 = \$184.35. Bonnie had to pay \$184.35 in interest charges to borrow \$950 for eighteen months.

See if you can solve the following interest questions with tables.

1. Find the values for $(1+i)^n$ using the compound interest table shown on the following page.

   a. $i = 6.5\%$ and $n = 29$

   b. $i = 4\%$ and $n = 17$

   c. $i = 8\%$ and $n = 22$

   d. $i = 5.5\%$ and $n = 13$

Compound Interest

n	3.5%	4%	4.5%	5%	5.5%	6%	6.5%	7%	7.5%	8%
1	1.035 000	1.040 000	1.045 000	1.050 000	1.055 000	1.060 000	1.065 000	1.070 000	1.075 000	1.080 000
2	1.071 225	1.081 600	1.092 025	1.102 500	1.113 025	1.123 600	1.134 225	1.144 900	1.155 625	1.166 400
3	1.108 718	1.124 864	1.141 166	1.157 625	1.174 241	1.191 016	1.207 950	1.225 043	1.242 297	1.259 712
4	1.147 523	1.169 859	1.192 519	1.215 506	1.238 825	1.262 477	1.286 466	1.310 796	1.335 469	1.360 489
5	1.187 686	1.216 653	1.246 182	1.276 282	1.306 960	1.338 226	1.370 087	1.402 552	1.435 629	1.469 328
6	1.229 255	1.265 319	1.302 260	1.340 096	1.378 843	1.418 519	1.459 142	1.500 730	1.543 302	1.586 874
7	1.272 279	1.315 932	1.360 862	1.407 100	1.454 679	1.503 630	1.553 987	1.605 781	1.659 049	1.713 824
8	1.316 809	1.368 569	1.422 101	1.477 455	1.534 687	1.593 848	1.654 996	1.718 186	1.783 478	1.850 930
9	1.362 897	1.423 312	1.486 095	1.551 328	1.619 094	1.689 479	1.762 570	1.838 459	1.917 239	1.999 005
10	1.410 599	1.480 244	1.552 969	1.628 895	1.708 144	1.790 848	1.877 137	1.967 151	2.061 032	2.158 925
11	1.459 970	1.539 454	1.622 853	1.710 339	1.802 092	1.898 299	1.999 151	2.104 852	2.215 609	2.331 639
12	1.511 069	1.601 032	1.695 881	1.795 856	1.901 207	2.012 196	2.129 096	2.252 192	2.381 780	2.518 170
13	1.563 956	1.665 074	1.772 196	1.885 649	2.005 774	2.132 928	2.267 487	2.409 845	2.560 413	2.719 624
14	1.618 695	1.731 676	1.851 945	1.979 932	2.116 091	2.260 904	2.414 874	2.578 534	2.752 444	2.937 194
15	1.675 349	1.800 944	1.935 282	2.078 928	2.232 476	2.396 558	2.571 841	2.759 032	2.958 877	3.172 169
16	1.733 986	1.872 981	2.022 370	2.182 875	2.355 263	2.540 352	2.739 011	2.952 164	3.180 793	3.425 943
17	1.794 676	1.947 900	2.113 377	2.292 018	2.484 802	2.692 773	2.917 046	3.158 815	3.419 353	3.700 018
18	1.857 489	2.025 817	2.208 479	2.406 619	2.621 466	2.854 339	3.106 654	3.379 932	3.675 804	3.996 019
19	1.922 501	2.106 849	2.307 860	2.526 950	2.765 647	3.025 600	3.308 587	3.616 528	3.951 489	4.315 701
20	1.989 789	2.191 123	2.411 714	2.653 298	2.917 757	3.207 135	3.523 645	3.869 684	4.247 851	4.660 957
21	2.059 431	2.278 768	2.520 241	2.785 963	3.078 234	3.399 564	3.752 682	4.410 562	4.566 440	5.033 834
22	2.131 512	2.369 919	2.633 652	2.925 261	3.247 537	3.603 537	3.996 606	4.430 402	4.908 923	5.436 540
23	2.206 114	2.464 716	2.752 166	3.071 524	3.426 152	3.819 750	4.256 386	4.740 530	5.277 092	5.871 464
24	2.283 328	2.563 304	2.876 014	3.225 100	3.614 590	4.048 935	4.533 051	5.072 367	5.672 874	6.341 181
25	2.363 245	2.665 836	3.005 434	3.386 355	3.813 392	4.291 871	4.827 699	5.427 433	6.098 340	6.848 475
26	2.445 959	2.772 470	3.140 679	3.555 673	4.023 129	4.549 383	5.141 500	5.807 353	6.555 715	7.396 353
27	2.531 567	2.883 369	3.282 010	3.733 456	4.244 401	4.822 346	5.475 697	6.213 868	7.047 394	7.988 061
28	2.620 172	2.998 703	3.429 700	3.920 129	4.477 843	5.111 687	5.831 617	6.648 838	7.575 948	8.627 106
29	2.711 878	3.118 651	3.584 036	4.116 136	4.724 124	5.418 388	6.210 672	7.114 257	8.144 144	9.317 275
30	2.806 794	3.243 398	3.745 318	4.321 942	4.983 951	5.743 491	6.614 366	7.612 255	8.754 955	10.062 657
31	2.905 031	3.373 133	3.913 857	4.538 039	5.258 069	6.088 101	7.044 300	8.145 113	9.411 577	10.867 669
32	3.006 708	3.508 059	4.089 981	4.764 941	5.547 262	6.453 387	7.502 179	8.715 271	10.117 445	11.737 083
33	3.111 942	3.648 381	4.274 030	5.003 189	5.852 362	6.840 590	7.989 821	9.325 340	10.876 253	12.676 050
34	3.220 860	3.794 316	4.466 362	5.253 348	6.174 242	7.251 025	8.590 159	9.978 114	11.691 972	13.690 134
35	3.333 590	3.946 089	4.667 348	5.516 015	6.513 825	7.686 087	9.062 255	10.676 581	12.568 870	14.785 344

2. Complete the following table using the values for $(1+i)^n$ in question 1.

Value for $(1+i)^n$	Principal (P)	Amount to Be Repaid	Amount of Interest Paid ($I = A - P$)
1 a.	$2000		
1 b.	$2000		
1 c.	$2000		
1 d.	$2000		

3. Wayne Scarealot opened a savings account with the Bank of Big Business, depositing $7000. The interest on his savings account is compounded quarterly at 10% per annum. Six months later, Wayne deposited $2500 more into the account. Use the compound interest tables in **Appendix B** to find each of the following:

   a. the amount in Wayne's savings account after 6 months (before the second deposit)

   b. the amount in the account after one year

4. Madeline Rose borrowed $5000 from her local bank at 14% per annum compounded semiannually. She invested the money in the Government of Canada Bonds which paid her 12% per annum compounded quarterly. Use the compound interest tables in **Appendix B** to help answer the following questions.

   a. Will Madeline earn or lose money after two years?

   b. How much did Madeline earn or lose?

For solutions to **Activity 3**, turn to **Appendix A, Topic 1.**

If you require help, do the Extra Help section.

If you want more challenging explorations, do the Extensions section.

} You may decide to do both.

Extra Help

In previous courses, calculations of interest earned or owed have been made using the simple interest formula $I = P \times r \times t$. In reality, however, banks, credit card companies, and other major institutions use the compound interest formula to calculate the interest to be paid toward a savings account or to be charged on a balance due. Compound interest can be defined as the interest earned on the principal and any interest earned in previous interest periods.

This unit has introduced you to three different methods which can be used to calculate the amount of compound interest. Compound interest can be calculated using any of the following methods.

- repeated simple interest calculations
- a scientific calculator and the compound interest formula $A = P(1+i)^n$
- a basic calculator and the compound interest tables

Review each of these methods for calculating compound interest by solving the following problem.

Example 4

Mark Treflin has just purchased $1300 worth of Guaranteed Investment Certificates (G.I.C.'s) which pay interest at a rate of 12% per annum compounded semiannually. How much will Mark's G.I.C.'s be worth after two years?

Solution:

Method 1: Repeated Simple Interest Calculations

This method will allow you to calculate the amount of interest earned by the G.I.C.'s for each six-month term. This interest is then added to the original principal to become the starting principal for the second term. Use the formula $I = P \times r \times t$.

$I = ?$ $\quad P = \$1300$ $\quad r = 12\%$

$= 0.12$

$$n = \frac{6 \text{ months}}{12 \text{ months}}$$

$$= \frac{1}{2} \text{ year}$$

You can now complete the following table.

Semiannually (6 month term)	Principal plus Previous Interest	Simple Interest per Term (Use $I = P \times r \times t$)
1st	\$1300	$I = \$1300 \times 0.12 \times \frac{1}{2} = \$78.00$
2nd	\$1300 + \$78 = \$1378.00	$I = \$1378 \times 0.12 \times \frac{1}{2} = \$82.68$
3rd	\$1378 + \$82.68 = \$1460.68	$I = \$1460.68 \times 0.12 \times \frac{1}{2} = \$87.64$
4th	\$1460.68 + \$87.64 = \$1548.32	$I = \$1548.32 \times 0.12 \times \frac{1}{2} = \$92.90$

Mark's G.I.C.'s will be worth \$1548.32 + \$92.90 = \$1641.22. That's \$1641.22 – \$1300 or \$341.22 in interest that Mark earned in two years.

Method 2: The Compound Interest Formula

You can calculate the amount Mark's G.I.C.'s are worth in two years using the formula $A = P(1+i)^n$, where

$A = ?$ $P = \$1300$

$n =$ number of periods per annum $\times$ number of years

$n = 2 \times 2$

$= 4$

$$i = \frac{\text{interest rate per annum}}{\text{number of interest periods in a year}}$$

$$i = \frac{12\%}{2}$$

$$= 6\%$$

$$= 0.06$$

You would now subsitute these values into the compound interest formula.

$A = \$1300(1+0.06)^4$

You can use your calculator to solve for A by following these steps.

Enter	Display
C	0
1.06	1.06
x^y	1.06
4	4
×	1.26247696
1300	1300
=	1641.220048

Mark's G.I.C.'s would be worth $1641.22 after two years.

Notice that this is the same answer as you derived with Method 1.

Now try Method 3.

Method 3: Compound Interest Tables

The compound interest tables give you the value for $(1+i)^n$ once you determine the interest rate per period (i) and the number of compounding periods (n).

To find the value of Mark's G.I.C.'s after two years, you must use the formula $A = P(1+i)^n$. You already know that

$$i = \frac{12\%}{2} \quad \text{and} \quad n = 2 \times 2$$
$$= 6\% \qquad\qquad = 4$$

Use these numbers to find the value for $(1+0.06)^4$ from the compound interest table. Note: 6% is the value for i, and 4 is the number of compounding periods (n).

Compound Interest

n	3.5%	4%	4.5%	5%	5.5%	6%	6.5%	7%	7.5%	8%
1	1.035 000	1.040 000	1.045 000	1.050 000	1.055 000	1.060 000	1.065 000	1.070 000	1.075 000	1.080 000
2	1.071 225	1.081 600	1.092 025	1.102 500	1.113 025	1.123 600	1.134 225	1.144 900	1.155 625	1.166 400
3	1.108 718	1.124 864	1.141 166	1.157 625	1.174 241	1.191 016	1.207 950	1.225 043	1.242 297	1.259 712
4	1.147 523	1.169 859	1.192 519	1.215 506	1.238 825	1.262 477	1.286 466	1.310 796	1.335 469	1.360 489
5	1.187 686	1.216 653	1.246 182	1.276 282	1.306 960	1.338 226	1.370 087	1.402 552	1.435 629	1.469 328
6	1.229 255	1.265 319	1.302 260	1.340 096	1.378 843	1.418 519	1.459 142	1.500 730	1.543 302	1.586 874
7	1.272 279	1.315 932	1.360 862	1.407 100	1.454 679	1.503 630	1.553 987	1.605 781	1.659 049	1.713 824
8	1.316 809	1.368 569	1.422 101	1.477 455	1.534 687	1.593 848	1.654 996	1.718 186	1.783 478	1.850 930
9	1.362 897	1.423 312	1.486 095	1.551 328	1.619 094	1.689 479	1.762 570	1.838 459	1.917 239	1.999 005
10	1.410 599	1.480 244	1.552 969	1.628 895	1.708 144	1.790 848	1.877 137	1.967 151	2.061 032	2.158 925

The value from the table is now plugged into the formula $A = P(1+i)^n$.

$A = \$1300(1.262\ 477)$

$= \$1641.2201$

$= \$1641.22$ (rounded to the nearest cent)

Whatever method you choose to use, the answer to Mark's problem is always the same. He would receive $1641.22 for his G.I.C.'s after two years.

Use the method you feel comfortable with to solve the following compound interest problems.

Do these questions.

1. Jennifer has charged $2600 worth of merchandise on her Worldwide credit card. She plans on paying the bill three months later. The credit card company charges 27%/a compounded monthly on any overdue balance in an account. How much will Jennifer owe after three months?

2. Ken opened an investment chequing account at his local Credit Union. The account pays interest at a rate of 10% per annum compounded quarterly if a minimum balance of $5000 is maintained in the account. Calculate the amount of interest Ken would receive on an initial deposit of $12 000 after 7 years.

For solutions to **Extra Help**, turn to **Appendix A, Topic 1.**

Extensions

Renée Bouchard plans on attending the University of Red Deer in two years. Renée has estimated that she will need $6500 for expenses in the first year of university. How much would Renée have to invest now to have $6500 in two years, if the best two-year interest rate available is 11% per annum compounded quarterly?

Can you solve this problem using the compound interest formula?

Yes you can! The standard compound interest formula can be rearranged to solve for the original principal P instead of the amount A after two years.

Using the compound interest formula $A = P(1+i)^n$, you can isolate P by dividing both sides of the equation by $(1+i)^n$.

$$\frac{A}{(1+i)^n} = \frac{P\cancel{(1+i)^n}}{\cancel{(1+i)^n}}$$

(1 over the numerator, 1 over the denominator)

Therefore, $\frac{A}{(1+i)^n} = P$ or $P = \frac{A}{(1+i)^n}$.

$(1+i)^n$ divides out, leaving $\frac{P \times 1}{1} = P$.

This formula can now be used to find the original principal, given the interest rate per period, the number of compounding periods, and the amount desired. When solving questions using this formula, P is normally referred to as the **present value**, indicating the amount which would have to be deposited at the **present time** to arrive at the desired amount in the future.

Find the present value required for Renée's first-year university expenses.

Example 5

Renée needs $6500 in two years to be able to attend the University of Red Deer. Determine the present value required given an interest rate of 11%/a compounded quarterly.

Solution:

Use the formula $P = \dfrac{A}{(1+i)^n}$, where

$P = ?$ $A = \$6500$ $i = \dfrac{11\%}{4}$

$= 2.75\%$

$= 0.0275,$

and $n = 4 \times 2$

$= 8$ compounding periods.

You can now substitute these values into the present value formula.

$$P = \frac{\$6500}{(1+0.0275)^8}$$

You can use your calculator to solve for P by following these steps.

Enter	Display
C	0
6500	6500
÷	6500
1.0275	1.0275
x^y	1.0275
8	8
=	5231.8913

Renée would have to deposit $5231.89 into an account now to have $6500 in two years.

Try to extend yourself with the following questions.

1. Use the values in the table to calculate the present values.

Amount Desired	Interest Rate per Period	Number of Compounding Periods	Present Value
$1500	3.5%	12	
$6200	7%	8	
$10 000	2.25%	24	
$4100	12%	3	
$2700	6.25%	10	

2. The Staylean Fitness Centre would like to sponsor a bodybuilding competition in eight months. Expenses and prize money have been budgeted at $3800.00. How much money would the Fitness Centre need to invest now to have $3800 in eight months, if the best interest rate available is 13% per annum compounded monthly?

3. Roger Danner wants to set aside $10 000 for his son's education. Roger's son is only five years old and will not need the money for twelve years. How much would Roger have to deposit now, at 8% per annum compounded semiannually, to receive $10 000 after twelve years?

For solutions to **Extensions**, turn to **Appendix A, Topic 1.**

In this unit, you calculated compound interest using three different methods: repeated simple interest calculations, the compound interest formula using a scientific calculator, and compound interest tables using a basic calculator. A fourth method is becoming commonplace in the business world, the microcomputer.

In this part of the Extensions section, you will use the Apple II microcomputer and the Appleworks™ [1] spreadsheet software to do these calculations.

This material is only meant for those students that have access to the Appleworks™ [1] software and an Apple IIe, IIc, or IIgs microcomputer and are familiar with the use and commands of the Appleworks™ [1] spreadsheet. The instructions in this section will be given in general terms to allow students to translate the steps and commands for other spreadsheets and microcomputers.

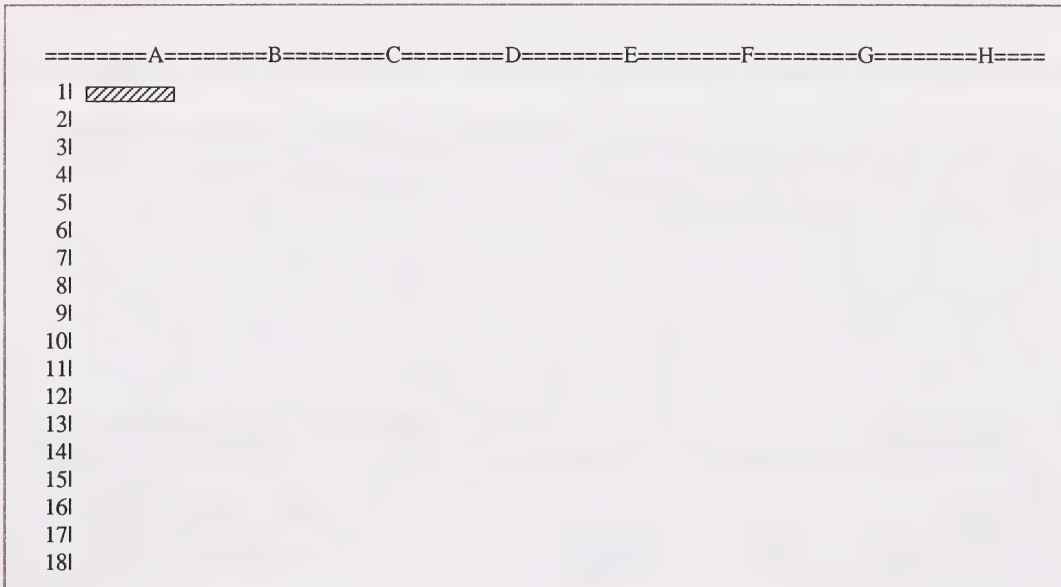
Examine the following situation.

Karen Lee deposits $3500 into a savings account that pays interest twelve times a year. If the account pays $8\frac{3}{4}$%/a, how much money will be in the account at the end of each month for two years?

Using any one of the three previous methods will be very time consuming. However, this type of repetitive task is very simple for the microcomputer.

Boot up your Apple microcomputer using Appleworks™ [1], and enter the spreadsheet application. Your screen should appear similar to the following.

[1] Appleworks™ is a title of Claris Incorporation Publishing Company.



Starting in cell A1, type "Compound Interest Calculations." The cell will only hold eight characters, but the application will automatically use the cells to the right of cell A1 as they are needed.
Now move to the following cells and enter the given text.

Cell	Text
A3	Principal
D3	n
E3	Amount
A4	Interest/a
A5	Compounding
A6	periods/a

Your labels should appear similar to the following screen.

```
========A========B========C========D========E========F========G========H====
 1| Compound Interest Calculations
 2|
 3| Principal                          n          Amount
 4| Interest/a
 5| Compounding
 6| periods/a
 7|
 8|
 9|
10|
11|
12|
13|
14|
15|
16|
17|
18|
--------------------------------------------------------------------------------
A6: (Label) periods/a
```

Now move to cell D4 and enter the number 1. Up to this point, the application has been entering the labels starting at the left side of the screen. The number 1, being a value, is entered on the right side of the cell.

Move down one cell and enter the number 2. Continue to move down and enter the next larger natural number until you have entered the number 24. The number 24 should appear in line 27.

This column of numbers will represent the 24 periods that will be paid into the account over the two years. After you move the cursor to the top of the spreadsheet, your screen should be similar to the following.

```
========A========B========C========D========E========F========G========H====
 1|  Compound Interest Calculations
 2|
 3|  Principal                          n          Amount
 4|  Interest/a                         1
 5|  Compounding                        2
 6|  periods/a                          3
 7|                                     4
 8|                                     5
 9|                                     6
10|                                     7
11|                                     8
12|                                     9
13|                                    10
14|                                    11
15|                                    12
16|                                    13
17|                                    14
18|                                    15
```

D1:

Move the cursor to cell E4.

In the column starting at cell E4 and ending at cell E27, you will enter the compound interest formula on each line. Then you will use the copy command to copy this formula to the other lines. In cell E4, enter +C3*(1 + (C4/(C6*100))) ^D4, and press the Return key.

Your screen should appear similar to the following.

```
========A========B========C========D========E========F========G========H====
 1| Compound Interest Calculations
 2|
 3| Principal                          n          Amount
 4| Interest/a                         1                0
 5| Compounding                        2
 6| periods/a                          3
 7|                                    4
 8|                                    5
 9|                                    6
10|                                    7
11|                                    8
12|                                    9
13|                                   10
14|                                   11
15|                                   12
16|                                   13
17|                                   14
18|                                   15
```

E4: (Value) +C3*(1 + (C4/(C6*100))) ^D4

Now use the copy command to copy this formula to cells E5 to E27. When copying, be sure to copy C3, C4, and C6 in the formula exactly as they are and copy D4 **relatively**. The D4 refers to how many periods have elapsed. In this case, one period has elapsed. In cell E5, the formula will contain the expression D5 instead of D4.

When your cursor is on cell E18, your screen should be similar to the following.

	A	B	C	D	E	F	G	H
1	Compound Interest Calculations							
2								
3	Principal		n		Amount			
4	Interest/a			1	0			
5	Compounding			2	0			
6	periods/a			3	0			
7				4	0			
8				5	0			
9				6	0			
10				7	0			
11				8	0			
12				9	0			
13				10	0			
14				11	0			
15				12	0			
16				13	0			
17				14	0			
18				15	0			

E18: (Value) +C3*(1 + (C4/(C6*100))) ^D18

Now is the time to enter the values of the problem.

In cell C3, enter the principal, $3500.
In cell C4, enter the interest rate per annum, 8.75.
In cell C6, enter the number of periods, 12.

After you have pressed the Return key after entering the number 12, the application will calculate the amount of money present in the account after each period.

Your spreadsheet should be similar to the following two screens.

Note: Format the column E to show values in dollars.

```
========A========B========C========D========E========F========G========H====
 1|  Compound Interest Calculations
 2|
 3|  Principal                3500 n        Amount
 4|  Interest/a                8.75          1     3525.52
 5|  Compounding                             2     3551.23
 6|  periods/a                   12          3     3577.12
 7|                                          4     3603.21
 8|                                          5     3629.48
 9|                                          6     3655.94
10|                                          7     3682.60
11|                                          8     3709.45
12|                                          9     3736.50
13|                                         10     3763.75
14|                                         11     3791.19
15|                                         12     3818.84
16|                                         13     3846.68
17|                                         14     3874.73
18|                                         15     3902.99
```

C6: (Value) 24

```
========A========B========C========D========E========F========G========H====

10|                                        7    3682.60
11|                                        8    3709.45
12|                                        9    3736.50
13|                                       10    3763.75
14|                                       11    3791.19
15|                                       12    3818.84
16|                                       13    3846.68
17|                                       14    3874.73
18|                                       15    3902.99
19|                                       16    3931.45
20|                                       17    3960.12
21|                                       18    3988.99
22|                                       19    4018.08
23|                                       20    4047.38
24|                                       21    4076.89
25|                                       22    4106.62
26|                                       23    4136.56
27|                                       24    4166.72
--------------------------------------------------------------------------------
A27:
```

The column under the label Amount is the 24 amounts of money that will be present in Karen Lee's account after each month.

This problem can easily be changed to fit any similar situation. You may need more or fewer compounding periods which you can easily copy. All you need to change are the three numbers that represent the principal, interest rate per annum, and the number of compounding periods per annum.

Try the following question.

4. The above spreadsheet can easily be changed to find the present value of an amount. The change can be done by following these steps.

1. In cell A3, type Amount.
2. In cell E3, type Principal.
3. In cell E4, type the formula +C3/(1 + (C4/C6 * 100) ^ D4).
4. Copy cell E4 into cells E5 to E27. (Copy C3, C4, and C6 exactly and D4 relatively).

a. Explain the meaning of the values in cells E4 to E27.
b. What are the values in cells E4 to E27?

For solutions to **Extensions**, turn to **Appendix A, Topic 1.**

Unit Summary

What You Have Learned

Compound interest can be defined as the interest paid on the sum of the principal and any previous interest. This means that interest paid on the balance in your savings account for one month becomes part of the principal for the next month. In other words, you earn interest on interest.

In this unit, you have learned three different methods for calculating compound interest. You should be able to use the following:

- repeated interest calculations to determine the amount of compound interest
- the compound interest formula $A = P(1+i)^n$ and a scientific calculator to determine the amount of compound interest
- compound interest tables to calculate compound interest

With these methods, you can determine the interest charges on credit card accounts and consumer loans or interest earned on savings accounts and other investments. The compound interest formula allows you to be a better consumer, being able to choose the best interest rate, 12% per annum compounded semiannually or 11% per annum compounded quarterly. Which one would you choose?

You are now ready to complete the **Unit Assignment.**

Appendices

Appendix A
Solutions

Review

Topic 1 Compound Interest

Appendix B
Charts and Tables

Compound Interest Tables

Appendix A
Solutions

Review

1. Remember to write the number as a fraction with either 12 (months) or 365 (days) in the denominator.

   a. $15 \text{ months} = \frac{15}{12} \text{ years}$
   $= 1\frac{3}{12} \text{ years}$ (Convert the improper fraction to a mixed fraction.)
   $= 1\frac{1}{4} \text{ years}$

   b. $225 \text{ days} = \frac{225}{365} \text{ years}$
   $= \frac{45}{73} \text{ years}$

   c. $22 \text{ months} = \frac{22}{12} \text{ years}$
   $= 1\frac{10}{12} \text{ years}$
   $= 1\frac{5}{6} \text{ years}$

   d. $146 \text{ days} = \frac{146}{365} \text{ years}$ (Divide both the numerator and denominator by 73.)
   $= \frac{2}{5} \text{ years}$

2. a. $6\frac{3}{4}\% = \frac{6\frac{3}{4}}{100}$
   $= \frac{6.75}{100}$
   $= 0.0675$

   b. $9\% = \frac{9}{100}$
   $= 0.09$

   c. $13\frac{1}{2}\% = \frac{13\frac{1}{2}}{100}$
   $= \frac{13.5}{100}$
   $= 0.135$

   d. $4\frac{1}{4}\% = \frac{4\frac{1}{4}}{100}$
   $= \frac{4.25}{100}$
   $= 0.0425$

3. a.

Enter	Display
C	0
2.75	2.75
x^y	2.75
4	4
=	57.19140624

   $(2.75)^4 \doteq 57.1914$ (rounded to 4 decimal places)

b. $(8.9)^2 = 8.9 \times 8.9$

$= 79.21$ or

Enter 8.9, press the power key $[y^x]$, enter the exponent 2, and press the equal key $[=]$.

$(8.9)^2 = 79.21$

c. $(1.025)^6 = 1.159693418$

$\doteq 1.1597$ (rounded to 4 decimal places)

d. $(4.35)^{12} \doteq 45906172.41$

4. a. $I = P \times r \times t$

Substitute the values into the formula.

$I = \$20\,000 \times \frac{9.5}{100} \times 2$

$= \$3800.00$

b. $I = P \times r \times t$

$I = \$4000 \times 0.05 \times \frac{99}{365}$

$= \$54.25$

5. Use the simple interest formula to calculate the money owed.

$I = ?$ $P = \$2200.00$ $r = 14\frac{1}{4}\%$ $t = \frac{1}{12}$ years

$I = \$2200 \times 0.1425 \times \frac{1}{12}$

$= \$26.125$

$= \$26.13$ (rounded to the nearest cent)

Arlene would have to pay \$26.13 in interest charges on the \$2200.00 borrowed for one month.

Exploring Topic 1

Activity 1

Use repeated simple interest calculations to determine the amount of compound interest.

1. a. $I_1 = \$650 \times 0.085 \times \frac{6}{12}$

$= \$27.63$ (interest after 1st period)

$I_2 = \$677.63 \times 0.085 \times \frac{6}{12}$

$= \$28.80$ (interest after 2nd period)

I_1 stands for interest after the 1st compounding period, and I_2 stands for the interest after the 2nd compounding period.

b. $I_1 = \$2500 \times 0.16 \times \frac{3}{12}$

$= \$100$

$I_2 = \$2600 \times 0.16 \times \frac{3}{12}$

$= \$104$

c. $I_1 = \$1400 \times 0.125 \times \frac{1}{12}$

$= \$14.58$

$I_2 = \$1414.58 \times 0.125 \times \frac{1}{12}$

$= \$14.74$

2. Martin Singh invested \$3700.00 at $11\frac{1}{4}\%$ compounded quarterly for fifteen months. This means that Martin would receive interest every three months or 5 times. You must use the simple interest formula 5 times.

$I = ?$ $P = \$3700.00$ $r = 11\frac{1}{4}\%$ $t = \frac{3}{12}$

$= 0.25$

$I_1 = \$3700 \times 0.1125 \times 0.25$

$= \$104.06$

$I_2 = \$3804.06 \times 0.1125 \times 0.25$

$= \$106.99$

$I_3 = \$3911.05 \times 0.1125 \times 0.25$

$= \$110.00$

$I_4 = \$4021.05 \times 0.1125 \times 0.25$

$= \$113.09$

$I_5 = \$4134.14 \times 0.1125 \times 0.25$

$= \$116.27$

Total interest = \$104.06 + \$106.99 + \$110.00 + \$113.09 + \$116.27

= \$550.41

Martin will receive a total of \$550.41 in interest on his original \$3700.00 deposit, after fifteen months.

3. Betty Lane borrowed \$650 from her credit card company for three months at a rate of 21% compounded monthly. Betty would have to pay interest for three compounding periods.

$I = ?$ $P = \$650$ $r = 21\%$ $t = \frac{1}{12}$

$I_1 = \$650 \times 0.21 \times \frac{1}{12}$

$= \$11.38$

$I_2 = \$661.38 \times 0.21 \times \frac{1}{12}$

$= \$11.57$

$I_3 = \$672.95 \times 0.21 \times \frac{1}{12}$

$= \$11.78$

Total interest = \$11.38 + \$11.57 + \$11.78

= \$34.73

Betty will owe \$34.73 in interest charges after borrowing \$650.00 for three months.

Activity 2

Use the compound interest formula $A = P(1+i)^n$ and a calculator to calculate compound interest.

1. To solve for n use the formula
   n = number of interest periods per year × number of years.

   To solve for i use the formula

   $$i = \frac{\text{annual interest rate}}{\text{number of interest periods in a year}}.$$

Annual Rate of Interest	Compounding Period	Number of Years	Number of Compounding Periods (n)	Rate per Compounding Period (i)
10%	semiannually	6	**12**	**0.05**
13%	annually	8	**8**	**0.13**
9%	monthly	5	**60**	**0.0075**
8%	quarterly	7	**28**	**0.02**
5%	daily	2	**730**	**0.000 136 99**
$7\frac{1}{2}$ %	monthly	3	**36**	**0.006 25**
12%	semiannually	4	**8**	**0.06**

2. a. In each case, you would use the formula $A = P(1+i)^n$, where $P = \$6000$. n and i will vary with the compounding period.

i. $i = \dfrac{14\%}{12}$

$= \dfrac{0.14}{12}$

$= 0.011\,667$ interest per compounding period

$n = 12 \times 2$

$= 24$ compounding periods.

$A = \$6000(1+0.011\,667)^{24}$

$= \$6000(1.011\,667)^{24}$

$= \$6000(1.320\,997\,546)$

$= \$7925.99$

ii. $i = \dfrac{14\%}{2}$

$= \dfrac{0.14}{2}$

$= 0.07$

$n = 2 \times 2$

$= 4$

$A = \$6000(1+0.07)^4$

$A = \$6000(1.07)^4$

$= \$6000(1.310\,796\,01)$

$= \$7864.78$

iii. $i = \dfrac{14\%}{4}$

$= \dfrac{0.14}{4}$

$= 0.035$

$n = 4 \times 2$

$= 8$

$A = \$6000(1+0.035)^8$

$= \$6000(1.035)^8$

$= \$6000(1.316\,809\,037)$

$= \$7900.85$

iv. $i = \dfrac{14\%}{1}$

$= \dfrac{0.14}{1}$

$= 0.14$

$n = 1 \times 2$

$= 2$

$A = \$6000(1+0.14)^2$

$= \$6000(1.14)^2$

$= \$6000(1.2996)$

$= \$7797.60$

b. The best rate for Kelly would be iv or 14% per annum compounded annually. In this case, Kelly would only have to pay back \$7797.60, the least amount.

3. a. Principal (P) = \$3200

b. Compounding period $= \dfrac{\text{number of compounding periods}}{\text{number of years}}$

$= \dfrac{20}{5}$

$= 4$ periods per year

12 months $\div 4 = 3$ months

The interest would be compounded every three months.

c. Interest rate per annum = interest rate per period (i) $\times$ number of periods in a year

$= 0.03 \times 4$

$= 0.12$

$= 12\%$

The interest rate for the term deposit is 12% per annum.

d. Solve the compound interest formula given.

$A = \$3200(1 + 0.03)^{20}$

$= \$3200(1.03)^{20}$

$= \$3200(1.806\ 111\ 235)$

$= \$5779.56$

After five years, Eldon would have \$5779.56 in the term deposit.

4. To calculate compound interest, use the formula $A = P(1+i)^n$.

a. $P = \$620$ $\quad i = \dfrac{9\%}{365}$ $\quad n = 90$

$= \dfrac{0.09}{365}$

$= 0.000\ 246\ 575$

$A = \$620(1 + 0.000\ 246\ 575)^{90}$

$= \$620(1.000\ 246\ 575)^{90}$

$= \$620(1.022\ 437\ 022)$

$= \$633.91$

Maria would have \$633.91 in her account after 90 days.

b. $P = \$620$ $\quad i = 0.000\ 246\ 575$ $\quad n = 230$

$A = \$620(1 + 0.000\ 246\ 575)^{230}$

$= \$620(1.000\ 246\ 575)^{230}$

$A = \$620(1.058\ 343\ 827)$

$= \$656.17$

Maria would have \$656.17 in her account after 230 days.

5. Your completed table should look like the following.

Principal (P)	Interest Rate per Compounding Period (i)	Number of Compounding Periods (n)	Amount $A = P(1+i)^n$
\$1400	0.055	6	**\$1930.38**
\$1400	0.055	8	**\$2148.56**
\$1400	0.055	10	**\$2391.40**
\$1400	0.055	12	**\$2661.69**
\$1400	0.055	13	**\$2808.08**
\$1400	0.055	14	**\$2962.53**

Jill would double her money after 13 periods or $13 \div 2 = 6.5$ years.

Activity 3

Calculate compound interest using compound interest tables.

1. The values for $(1+i)^n$ can be found using compound interest tables if you know the values for i and n. These values specify the row and column to be used to find the intersected value, $(1+i)^n$.

   a. 6.210 672

   b. 1.947 900

   c. 5.436 540

   d. 2.005 774

Compound Interest

n	3.5%	4%	4.5%	5%	5.5%	6%	6.5%	7%	7.5%	8%
1	1.035 000	1.040 000	1.045 000	1.050 000	1.055 000	1.060 000	1.065 000	1.070 000	1.075 000	1.080 000
2	1.071 225	1.081 600	1.092 025	1.102 500	1.113 025	1.123 600	1.134 225	1.144 900	1.155 625	1.166 400
3	1.108 718	1.124 864	1.141 166	1.157 625	1.174 241	1.191 016	1.207 950	1.225 043	1.242 297	1.259 712
4	1.147 523	1.169 859	1.192 519	1.215 506	1.238 825	1.262 477	1.286 466	1.310 796	1.335 469	1.360 489
5	1.187 686	1.216 653	1.246 182	1.276 282	1.306 960	1.338 226	1.370 087	1.402 552	1.435 629	1.469 328
6	1.229 255	1.265 319	1.302 260	1.340 096	1.378 843	1.418 519	1.459 142	1.500 730	1.543 302	1.586 874
7	1.272 279	1.315 932	1.360 862	1.407 100	1.454 679	1.503 630	1.553 987	1.605 781	1.659 049	1.713 824
8	1.316 809	1.368 569	1.422 101	1.477 455	1.534 687	1.593 848	1.654 996	1.718 186	1.783 478	1.850 930
9	1.362 897	1.423 312	1.486 095	1.551 328	1.619 094	1.689 479	1.762 570	1.838 459	1.917 239	1.999 005
10	1.410 599	1.480 244	1.552 969	1.628 895	1.708 144	1.790 848	1.877 137	1.967 151	2.061 032	2.158 925
11	1.459 970	1.539 454	1.622 853	1.710 339	1.802 092	1.898 299	1.999 151	2.104 852	2.215 609	2.331 639
12	1.511 069	1.601 032	1.695 881	1.795 856	1.901 207	2.012 196	2.129 096	2.252 192	2.381 780	2.518 170
13	1.563 956	1.665 074	1.772 196	1.885 649	2.005 774	2.132 928	2.267 487	2.409 845	2.560 413	2.719 624
14	1.618 695	1.731 676	1.851 945	1.979 932	2.116 091	2.260 904	2.414 874	2.578 534	2.752 444	2.937 194
15	1.675 349	1.800 944	1.935 282	2.078 928	2.232 476	2.396 558	2.571 841	2.759 032	2.958 877	3.172 169
16	1.733 986	1.872 981	2.022 370	2.182 875	2.355 263	2.540 352	2.739 011	2.952 164	3.180 793	3.425 943
17	1.794 676	1.947 900	2.113 377	2.292 018	2.484 802	2.692 773	2.917 046	3.158 815	3.419 353	3.700 018
18	1.857 489	2.025 817	2.208 479	2.406 619	2.621 466	2.854 339	3.106 654	3.379 932	3.675 804	3.996 019
19	1.922 501	2.106 849	2.307 860	2.526 950	2.765 647	3.025 600	3.308 587	3.616 528	3.951 489	4.315 701
20	1.989 789	2.191 123	2.411 714	2.653 298	2.917 757	3.207 135	3.523 645	3.869 684	4.247 851	4.660 957
21	2.059 431	2.278 768	2.520 241	2.785 963	3.078 234	3.399 564	3.752 682	4.410 562	4.566 440	5.033 834
22	2.131 512	2.369 919	2.633 652	2.925 261	3.247 537	3.603 537	3.996 606	4.430 402	4.908 923	5.436 540
23	2.206 114	2.464 716	2.752 166	3.071 524	3.426 152	3.819 750	4.256 386	4.740 530	5.277 092	5.871 464
24	2.283 328	2.563 304	2.876 014	3.225 100	3.614 590	4.048 935	4.533 051	5.072 367	5.672 874	6.341 181
25	2.363 245	2.665 836	3.005 434	3.386 355	3.813 392	4.291 871	4.827 699	5.427 433	6.098 340	6.848 475
26	2.445 959	2.772 470	3.140 679	3.555 673	4.023 129	4.549 383	5.141 500	5.807 353	6.555 715	7.396 353
27	2.531 567	2.883 369	3.282 010	3.733 456	4.244 401	4.822 346	5.475 697	6.213 868	7.047 394	7.988 061
28	2.620 172	2.998 703	3.429 700	3.920 129	4.477 843	5.111 687	5.831 617	6.648 838	7.575 948	8.627 106
29	2.711 878	3.118 651	3.584 036	4.116 136	4.724 124	5.418 388	6.210 672	7.114 257	8.144 144	9.317 275
30	2.806 794	3.243 398	3.745 318	4.321 942	4.983 951	5.743 491	6.614 366	7.612 255	8.754 955	10.062 657
31	2.905 031	3.373 133	3.913 857	4.538 039	5.258 069	6.088 101	7.044 300	8.145 113	9.411 577	10.867 669
32	3.006 708	3.508 059	4.089 981	4.764 941	5.547 262	6.453 387	7.502 179	8.715 271	10.117 445	11.737 083
33	3.111 942	3.648 381	4.274 030	5.003 189	5.852 362	6.840 590	7.989 821	9.325 340	10.876 253	12.676 050
34	3.220 860	3.794 316	4.466 362	5.253 348	6.174 242	7.251 025	8.590 159	9.978 114	11.691 972	13.690 134
35	3.333 590	3.946 089	4.667 348	5.516 015	6.513 825	7.686 087	9.062 255	10.676 581	12.568 870	14.785 344

2. To find the amount to be repaid (A), multiply the principal (P) by the value for $(1+i)^n$ from the tables. The interest can then be calculated by simply subtracting the principal.

Value for $(1+i)^n$	Principal (P)	Amount to be Repaid	Amount of Interest Paid ($I = A - P$)
1 a.	$2000	**$12 421.34**	**$10 421.34**
1 b.	$2000	**$3895.80**	**$1895.80**
1 c.	$2000	**$10 873.08**	**$8873.08**
1 d.	$2000	**$4011.55**	**$2011.55**

3. a. Use the formula $A = P(1+i)^n$, where $P = \$7000$, $i = \frac{10\%}{4} = 2.5\%$, $n = \frac{6 \text{ months}}{3 \text{ months}} = 2$.

The value from the compound interest tables, where $i = 2.5\%$ and $n = 2$ would be 1.050 625. This value can be used to find the amount (A) in Wayne's account.

$A = \$7000(1.050\ 625)$

$= \$7354.38$

Wayne would have $7354.38 in his savings account after 6 months.

b. $A = ?$ $P = \$7354.38 + \$2500$

$= \$9854.38$

$i = 2.5\%$ per period

$n = \frac{6 \text{ months}}{3 \text{ months}}$

$= 2$

Note: The time period is only six months, since the interest has already been calculated for the first six months.

$A = \$9854.38(1.050\ 625)$

$= \$10\ 353.26$

Wayne would have \$10 353.26 in his savings account after one year.

4. a. Use the compound interest tables in **Appendix B**.

First, calculate the total amount that would have to be repaid after two years.

$A = ?$ $P = \$5000$ $i = \frac{14\%}{2}$

$= 7\%$ per period

$n = 2 \times 2$

$= 4$

$A = \$5000(1.310\ 796)$

$= \$6553.98$

Next, determine the total amount that would accumulate in the Government of Canada Bonds.

$A = ?$ $P = \$5000$ $i = \frac{12\%}{4}$

$= 3\%$ per period

$n = 4 \times 2$

$= 8$

$A = \$5000(1.266\ 770)$

$= \$6333.85$

Madeline would lose money after two years.

b. \$6553.98 – \$6333.85 = \$220.13

Madeline lost \$220.13 after two years of investing money in Government of Canada Bonds.

Extra Help

1. To find the amount Jennifer would owe Worldwide Credit Card Company, use the compound interest formula $A = P(1+i)^n$, where the following values are known.

$A = ?$ $\quad P = \$2600 \quad i = \dfrac{27\%}{12}$

$= 2.25\%$

$= 0.0225$

$n = 12 \times \dfrac{3}{12}$

$= 3$ compounding periods

The interest tables do not give the values for an interest rate of 2.25% so use your scientific calculator.

$A = \$2600(1+0.0225)^3$

Enter	Display
C	0
1.0225	1.0225
x^y	1.0225
3	3
×	1.069030141
2600	2600
=	2779.478366

Jennifer would have to pay Worldwide Credit Card Company $2779.48 after three months. There is $179.48 in interest charges after three months!

2. To calculate Ken's interest, you could use the compound interest tables.

$A = ?$ $\quad P = \$12\ 000 \quad i = \dfrac{10\%}{4}$

$= 2.5\%$

Interest is compounded quarterly, which is 4 times a year.

Remember, n = number of compounding periods per year × number of years.

$n = 4$ times per year $\times 7$ years

$= 28$

$A = \$12\ 000(1+0.025)^{28}$

From the compound interest tables in **Appendix B**,

$A = \$12\ 000(1.996\ 495)$

$= \$23\ 957.94.$

Interest = amount − principal

$= \$23\ 957.94 - \$12\ 000$

$= \$11\ 957.94$

Ken would earn $11 957.94 in interest after seven years on his $12 000 investment. That is almost double his money!

Extensions

1. Complete the following table.

Amount Desired	Interest Rate per Period	Number of Compounding Periods	Present Value
$1500	3.5%	12	**$992.67**
$6200	7%	8	**$3608.46**
$10 000	2.25%	24	**$5862.47**
$4100	12%	3	**$2918.30**
$2700	6.25%	10	**$1472.56**

2. To find the amount that the Fitness Centre must invest, use the present value formula

$P = \frac{A}{(1+i)^n}$, where the following values are known.

$P = ?$ $\quad A = \$3800$ $\quad i = \frac{13\%}{12} = \frac{0.13}{12} = 0.010\ 833\ 33$ $\quad n = 1 \times 8 = 8$ compounding periods

$$P = \frac{\$3800}{(1+0.010\ 833\ 33)^8}$$

$$= \frac{\$3800}{1.090\ 024\ 921}$$

$$= \$3486.15$$

The Staylean Fitness Centre would have to deposit $3486.15 to receive $3800 in eight months.

3. Use the present value formula $P = \frac{A}{(1+i)^n}$,

where the following values are known.

$P = ?$ $A = \$10\,000$ $i = \frac{8\%}{2}$

$= 4\%$

$= 0.04$

$n = 2 \times 12$

$= 24$ compounding periods

$$P = \frac{\$10\,000}{(1+0.04)^{24}}$$

$= \$3901.21$

Roger would have to deposit \$3901.21 to have \$10 000 in twelve years.

4. a. The values in cells E4 to E27 represent the principals that would yield the amount $3500 after the specified number of compounding periods.

b.

```
========A========B========C========D========E========F========G========H====
 1| Compound Interest Calculations
 2|
 3| Amount                3500 n          Principal
 4| Interest/a            8.75      1     3262.14
 5| Compounding                     2     3040.44
 6| periods/a               12      3     2833.81
 7|                                 4     2641.22
 8|                                 5     2461.72
 9|                                 6     2294.42
10|                                 7     2138.48
11|                                 8     1993.15
12|                                 9     1857.69
13|                                10     1731.44
14|                                11     1613.77
15|                                12     1504.10
16|                                13     1401.88
17|                                14     1306.60
18|                                15     1217.81
```

C6: (Value) 24

========A========B========C========D========E========F========G========H====

10		7	2138.48
11		8	1993.15
12		9	1857.69
13		10	1731.44
14		11	1613.77
15		12	1504.10
16		13	1401.88
17		14	1306.60
18		15	1217.81
19		16	1135.04
20		17	1057.90
21		18	986.01
22		19	919.00
23		20	856.54
24		21	798.33
25		22	744.07
26		23	693.51
27		24	646.37

- - - -

Appendix B

Interest Tables $(1+i)^n$ Compound Amount of 1

n	0.25%	0.5%	0.75%	1%	1.25%	1.5%	1.75%	2%	2.5%	3%
1	1.002 500	1.005 000	1.007 500	1.010 000	1.012 500	1.015 000	1.017 500	1.020 000	1.025 000	1.030 000
2	1.005 006	1.010 025	1.015 056	1.020 100	1.025 156	1.030 225	1.035 306	1.040 400	1.050 625	1.060 900
3	1.007 519	1.015 075	1.022 669	1.030 301	1.037 971	1.045 678	1.053 424	1.061 208	1.076 891	1.092 727
4	1.010 038	1.020 151	1.030 339	1.040 604	1.050 945	1.061 364	1.071 859	1.082 432	1.103 813	1.125 509
5	1.012 563	1.025 251	1.038 067	1.051 010	1.064 082	1.077 284	1.090 617	1.104 081	1.131 408	1.159 274
6	1.015 094	1.030 378	1.045 852	1.061 520	1.077 383	1.093 443	1.109 702	1.126 162	1.159 693	1.194 052
7	1.017 632	1.035 529	1.053 696	1.072 135	1.090 850	1.109 845	1.129 122	1.148 686	1.188 686	1.229 874
8	1.020 176	1.040 707	1.061 599	1.082 857	1.104 486	1.126 493	1.148 882	1.171 659	1.218 403	1.266 770
9	1.022 726	1.045 911	1.069 561	1.093 685	1.118 292	1.143 390	1.168 987	1.195 093	1.248 863	1.304 773
10	1.025 283	1.051 140	1.077 583	1.104 622	1.132 271	1.160 541	1.189 444	1.218 994	1.280 085	1.343 916
11	1.027 846	1.056 396	1.085 664	1.115 668	1.146 424	1.177 949	1.210 260	1.243 374	1.312 087	1.384 234
12	1.030 416	1.061 678	1.093 807	1.126 825	1.160 755	1.195 618	1.231 439	1.268 242	1.344 889	1.425 761
13	1.032 992	1.066 986	1.102 010	1.138 093	1.175 264	1.213 552	1.252 990	1.293 607	1.378 511	1.468 534
14	1.035 574	1.072 321	1.110 276	1.149 474	1.189 955	1.231 756	1.274 917	1.319 479	1.412 974	1.512 590
15	1.038 163	1.077 683	1.118 603	1.160 969	1.204 829	1.250 232	1.297 228	1.345 868	1.448 298	1.557 967
16	1.040 759	1.083 071	1.126 992	1.172 579	1.219 890	1.268 986	1.319 929	1.372 786	1.484 506	1.604 706
17	1.043 361	1.088 487	1.135 445	1.184 304	1.235 138	1.288 020	1.343 028	1.400 241	1.521 618	1.652 848
18	1.045 969	1.093 929	1.143 960	1.196 147	1.250 577	1.307 341	1.366 531	1.428 246	1.559 659	1.702 433
19	1.048 584	1.099 399	1.152 540	1.208 109	1.266 210	1.326 951	1.390 445	1.456 811	1.598 650	1.753 506
20	1.051 206	1.104 896	1.161 184	1.220 190	1.282 037	1.346 855	1.414 778	1.485 947	1.638 616	1.806 111
21	1.053 834	1.110 420	1.169 893	1.232 392	1.289 063	1.367 058	1.439 537	1.515 666	1.679 582	1.860 295
22	1.056 468	1.115 972	1.178 667	1.244 716	1.314 288	1.387 564	1.464 729	1.545 980	1.721 571	1.916 103
23	1.059 109	1.121 552	1.187 507	1.257 163	1.330 717	1.408 377	1.490 361	1.576 899	1.764 611	1.973 587
24	1.061 757	1.127 160	1.196 414	1.269 735	1.347 351	1.429 503	1.516 443	1.608 437	1.808 726	2.032 794
25	1.064 411	1.132 796	1.205 387	1.282 432	1.364 193	1.450 945	1.542 981	1.640 606	1.853 944	2.093 778

Interest Tables $(1+i)^n$ Compound Amount of 1 (Continued)

n	0.25%	0.5%	0.75%	1%	1.25%	1.5%	1.75%	2%	2.5%	3%
26	1.067 072	1.138 460	1.214 427	1.295 256	1.381 245	1.472 710	1.569 983	1.673 418	1.900 293	2.156 591
27	1.069 740	1.144 152	1.223 535	1.308 209	1.398 511	1.494 800	1.597 457	1.706 886	1.947 800	2.221 289
28	1.072 414	1.149 873	1.232 712	1.321 291	1.415 992	1.517 222	1.625 413	1.741 024	1.996 495	2.287 928
29	1.075 096	1.155 622	1.241 957	1.334 504	1.433 692	1.539 981	1.653 858	1.775 845	2.046 407	2.356 566
30	1.077 783	1.161 400	1.251 272	1.347 849	1.451 613	1.563 080	1.682 800	1.811 362	2.097 568	2.427 262
31	1.080 478	1.167 207	1.260 656	1.361 327	1.469 759	1.586 526	1.712 249	1.847 589	2.150 007	2.500 080
32	1.083 179	1.173 043	1.270 111	1.374 941	1.488 131	1.610 324	1.742 213	1.884 541	2.203 757	2.575 083
33	1.085 887	1.178 908	1.279 637	1.388 690	1.506 732	1.634 479	1.772 702	1.922 231	2.258 851	2.652 335
34	1.088 602	1.184 803	1.289 234	1.402 577	1.525 566	1.658 996	1.803 725	1.960 676	2.315 322	2.731 905
35	1.091 323	1.190 727	1.298 904	1.416 603	1.544 636	1.683 881	1.835 290	1.999 890	2.373 205	2.813 862
36	1.094 051	1.196 681	1.308 645	1.430 769	1.563 944	1.709 140	1.867 407	2.039 887	2.432 535	2.898 278
37	1.096 787	1.202 664	1.318 460	1.445 076	1.583 493	1.734 777	1.900 087	2.080 685	2.493 349	2.985 227
38	1.099 528	1.208 677	1.328 349	1.459 527	1.603 287	1.760 798	1.933 338	2.122 299	2.555 682	3.074 783
39	1.102 277	1.214 721	1.338 311	1.474 123	1.623 328	1.787 210	1.967 172	2.164 745	2.619 574	3.167 027
40	1.105 033	1.220 794	1.348 349	1.488 864	1.643 619	1.814 018	2.001 597	2.208 040	2.685 064	3.262 038
41	1.107 796	1.226 898	1.358 461	1.503 752	1.664 165	1.841 229	2.036 625	2.252 200	2.752 190	3.359 899
42	1.110 565	1.233 033	1.368 650	1.518 790	1.684 967	1.868 847	2.072 266	2.297 244	2.820 995	3.460 696
43	1.113 341	1.239 198	1.378 915	1.533 978	1.706 029	1.896 880	2.108 531	2.343 189	2.891 520	3.564 517
44	1.116 125	1.245 394	1.389 256	1.549 318	1.727 354	1.925 333	2.145 430	2.390 053	2.963 808	3.671 452
45	1.118 915	1.251 621	1.399 676	1.564 811	1.748 946	1.954 213	2.182 975	2.437 854	3.037 903	3.781 596
46	1.121 712	1.257 879	1.410 173	1.580 459	1.770 808	1.983 526	2.221 177	2.486 611	3.113 851	3.895 044
47	1.124 517	1.264 168	1.420 750	1.596 263	1.792 943	2.013 279	2.260 048	2.536 344	3.191 697	4.011 895
48	1.127 328	1.270 489	1.431 405	1.612 226	1.815 355	2.043 478	2.299 599	2.587 070	3.271 490	4.132 252
49	1.130 146	1.276 842	1.442 141	1.628 348	1.838 047	2.074 130	2.339 842	2.638 812	3.353 277	4.256 219
50	1.132 972	1.283 226	1.452 957	1.644 632	1.861 022	2.105 242	2.380 789	2.691 588	3.437 109	4.383 906

Compound Interest

n	3.5%	4%	4.5%	5%	5.5%	6%	6.5%	7%	7.5%	8%
1	1.035 000	1.040 000	1.045 000	1.050 000	1.055 000	1.060 000	1.065 000	1.070 000	1.075 000	1.080 000
2	1.071 225	1.081 600	1.092 025	1.102 500	1.113 025	1.123 600	1.134 225	1.144 900	1.155 625	1.166 400
3	1.108 718	1.124 864	1.141 166	1.157 625	1.174 241	1.191 016	1.207 950	1.225 043	1.242 297	1.259 712
4	1.147 523	1.169 859	1.192 519	1.215 506	1.238 825	1.262 477	1.286 466	1.310 796	1.335 469	1.360 489
5	1.187 686	1.216 653	1.246 182	1.276 282	1.306 960	1.338 226	1.370 087	1.402 552	1.435 629	1.469 328
6	1.229 255	1.265 319	1.302 260	1.340 096	1.378 843	1.418 519	1.459 142	1.500 730	1.543 302	1.586 874
7	1.272 279	1.315 932	1.360 862	1.407 100	1.454 679	1.503 630	1.553 987	1.605 781	1.659 049	1.713 824
8	1.316 809	1.368 569	1.422 101	1.477 455	1.534 687	1.593 848	1.654 996	1.718 186	1.783 478	1.850 930
9	1.362 897	1.423 312	1.486 095	1.551 328	1.619 094	1.689 479	1.762 570	1.838 459	1.917 239	1.999 005
10	1.410 599	1.480 244	1.552 969	1.628 895	1.708 144	1.790 848	1.877 137	1.967 151	2.061 032	2.158 925
11	1.459 970	1.539 454	1.622 853	1.710 339	1.802 092	1.898 299	1.999 151	2.104 852	2.215 609	2.331 639
12	1.511 069	1.601 032	1.695 881	1.795 856	1.901 207	2.012 196	2.129 096	2.252 192	2.381 780	2.518 170
13	1.563 956	1.665 074	1.772 196	1.885 649	2.005 774	2.132 928	2.267 487	2.409 845	2.560 413	2.719 624
14	1.618 695	1.731 676	1.851 945	1.979 932	2.116 091	2.260 904	2.414 874	2.578 534	2.752 444	2.937 194
15	1.675 349	1.800 944	1.935 282	2.078 928	2.232 476	2.396 558	2.571 841	2.759 032	2.958 877	3.172 169
16	1.733 986	1.872 981	2.022 370	2.182 875	2.355 263	2.540 352	2.739 011	2.952 164	3.180 793	3.425 943
17	1.794 676	1.947 900	2.113 377	2.292 018	2.484 802	2.692 773	2.917 046	3.158 815	3.419 353	3.700 018
18	1.857 489	2.025 817	2.208 479	2.406 619	2.621 466	2.854 339	3.106 654	3.379 932	3.675 804	3.996 019
19	1.922 501	2.106 849	2.307 860	2.526 950	2.765 647	3.025 600	3.308 587	3.616 528	3.951 489	4.315 701
20	1.989 789	2.191 123	2.411 714	2.653 298	2.917 757	3.207 135	3.523 645	3.869 684	4.247 851	4.660 957
21	2.059 431	2.278 768	2.520 241	2.785 963	3.078 234	3.399 564	3.752 682	4.410 562	4.566 440	5.033 834
22	2.131 512	2.369 919	2.633 652	2.925 261	3.247 537	3.603 537	3.996 606	4.430 402	4.908 923	5.436 540
23	2.206 114	2.464 716	2.752 166	3.071 524	3.426 152	3.819 750	4.256 386	4.740 530	5.277 092	5.871 464
24	2.283 328	2.563 304	2.876 014	3.225 100	3.614 590	4.048 935	4.533 051	5.072 367	5.672 874	6.341 181
25	2.363 245	2.665 836	3.005 434	3.386 355	3.813 392	4.291 871	4.827 699	5.427 433	6.098 340	6.848 475

Compound Interest (Continued)

n	3.5%	4%	4.5%	5%	5.5%	6%	6.5%	7%	7.5%	8%
26	2.445 959	2.772 470	3.140 679	3.555 673	4.023 129	4.549 383	5.141 500	5.807 353	6.555 715	7.396 353
27	2.531 567	2.883 369	3.282 010	3.733 456	4.244 401	4.822 346	5.475 697	6.213 868	7.047 394	7.988 061
28	2.620 172	2.998 703	3.429 700	3.920 129	4.477 843	5.111 687	5.831 617	6.648 838	7.575 948	8.627 106
29	2.711 878	3.118 651	3.584 036	4.116 136	4.724 124	5.418 388	6.210 672	7.114 257	8.144 144	9.317 275
30	2.806 794	3.243 398	3.745 318	4.321 942	4.983 951	5.743 491	6.614 366	7.612 255	8.754 955	10.062 657
31	2.905 031	3.373 133	3.913 857	4.538 039	5.258 069	6.088 101	7.044 300	8.145 113	9.411 577	10.867 669
32	3.006 708	3.508 059	4.089 981	4.764 941	5.547 262	6.453 387	7.502 179	8.715 271	10.117 445	11.737 083
33	3.111 942	3.648 381	4.274 030	5.003 189	5.852 362	6.840 590	7.989 821	9.325 340	10.876 253	12.676 050
34	3.220 860	3.794 316	4.466 362	5.253 348	6.174 242	7.251 025	8.590 159	9.978 114	11.691 972	13.690 134
35	3.333 590	3.946 089	4.667 348	5.516 015	6.513 825	7.686 087	9.062 255	10.676 581	12.568 870	14.785 344
36	3.450 266	4.103 933	4.877 378	5.791 816	6.872 085	8.147 252	9.651 301	11.423 942	13.511 536	15.968 172
37	3.571 025	4.268 090	5.096 860	6.081 407	7.250 050	8.636 087	10.278 636	12.223 618	14.524 901	17.245 626
38	3.696 011	4.438 813	5.326 219	6.385 477	7.648 803	9.154 252	10.946 747	13.079 271	15.614 268	18.625 276
39	3.825 372	4.616 366	5.565 899	6.704 751	8.069 487	9.703 507	11.658 286	13.994 820	16.785 339	20.115 298
40	3.959 260	4.801 021	5.816 365	7.039 989	8.513 309	10.285 718	12.416 075	14.974 458	18.044 239	21.724 521
41	4.097 834	4.993 061	6.078 101	7.391 988	8.981 541	10.902 861	13.223 119	16.022 670	19.397 557	23.462 483
42	4.241 258	5.192 784	6.351 615	7.761 588	9.475 525	11.557 033	14.082 622	17.144 257	20.852 372	25.339 482
43	4.389 702	5.400 495	6.637 438	8.149 667	9.996 679	12.250 455	14.997 993	18.344 355	22.416 302	27.366 640
44	4.543 342	5.616 515	6.936 123	8.557 150	10.546 497	12.985 482	15.972 862	19.628 460	24.097 524	29.555 972
45	4.702 359	5.841 176	7.248 248	8.985 008	11.126 554	13.764 611	17.011 098	21.002 452	25.904 839	31.920 449
46	4.866 941	6.074 823	7.574 420	9.434 258	11.738 515	14.590 487	18.116 820	22.472 623	27.847 702	34.474 085
47	5.037 284	6.317 816	7.915 268	9.905 971	12.384 133	15.465 917	19.294 413	24.045 707	29.936 279	37.232 012
48	5.213 589	6.570 528	8.271 456	10.401 270	13.065 260	16.393 872	20.548 550	25.728 907	32.181 500	40.210 573
49	5.396 065	6.833 349	8.643 671	10.921 333	13.783 849	17.377 504	21.884 205	27.529 930	34.595 113	43.427 419
50	5.584 927	7.106 683	9.032 636	11.467 400	14.541 961	18.420 154	23.306 679	29.457 025	37.189 746	46.901 613

Compound Interest

n	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%	12.5%
1	1.085 000	1.090 000	1.095 000	1.100 000	1.105 000	1.110 000	1.115 000	1.120 000	1.125 000
2	1.177 225	1.188 100	1.199 025	1.210 000	1.221 025	1.232 100	1.243 225	1.254 400	1.265 625
3	1.277 289	1.295 029	1.312 932	1.331 000	1.349 233	1.367 631	1.386 196	1.404 928	1.423 828
4	1.385 859	1.411 582	1.437 661	1.464 100	1.490 902	1.518 070	1.545 608	1.573 519	1.601 807
5	1.503 657	1.538 624	1.574 239	1.610 510	1.647 447	1.685 058	1.723 353	1.762 342	1.802 032
6	1.631 468	1.677 100	1.723 791	1.771 561	1.820 429	1.870 415	1.921 539	1.973 823	2.027 287
7	1.770 142	1.828 039	1.887 552	1.948 717	2.011 574	2.076 160	2.142 516	2.210 681	2.280 697
8	1.920 604	1.992 563	2.066 869	2.143 589	2.222 789	2.304 538	2.388 905	2.475 963	2.565 785
9	2.083 856	2.171 893	2.263 222	2.357 948	2.456 182	2.558 037	2.663 629	2.773 079	2.886 508
10	2.260 983	2.367 364	2.478 228	2.593 742	2.714 081	2.839 421	2.969 947	3.105 848	3.247 321
11	2.453 167	2.580 426	2.713 659	2.853 117	2.999 059	3.151 757	3.311 491	3.478 550	3.653 236
12	2.661 686	2.812 665	2.971 457	3.138 428	3.313 961	3.498 451	3.692 312	3.895 976	4.109 891
13	2.887 930	3.065 805	3.253 745	3.452 271	3.661 926	3.883 280	4.116 928	4.363 493	4.623 627
14	3.133 404	3.341 727	3.562 851	3.797 498	4.046 429	4.310 441	4.590 375	4.887 112	5.201 580
15	3.399 743	3.642 482	3.901 322	4.177 248	4.471 304	4.784 589	5.118 268	5.473 566	5.851 778
16	3.688 721	3.970 306	4.271 948	4.594 973	4.940 791	5.310 894	5.706 869	6.130 394	6.583 250
17	4.002 262	4.327 633	4.677 783	5.054 470	5.459 574	5.895 093	6.363 159	6.866 041	7.406 156
18	4.342 455	4.717 120	5.122 172	5.559 917	6.032 829	6.543 553	7.094 922	7.689 966	8.331 926
19	4.711 563	5.141 661	5.608 778	6.115 909	6.666 276	7.263 344	7.910 838	8.612 762	9.373 417
20	5.112 046	5.604 411	6.141 612	6.727 500	7.366 235	8.062 312	8.820 584	9.646 293	10.545 094
21	5.546 570	6.108 808	6.725 065	7.400 250	8.139 690	8.949 166	9.834 951	10.803 848	11.863 231
22	6.018 028	6.658 600	7.363 946	8.140 275	8.994 357	9.933 574	10.965 971	12.100 310	13.346 134
23	6.529 561	7.257 874	8.063 521	8.954 302	9.938 764	11.026 267	12.227 057	13.552 347	15.014 401
24	7.084 574	7.911 083	8.829 556	9.849 733	10.982 335	12.239 157	13.633 169	15.178 629	16.891 201
25	7.686 762	8.623 081	9.668 364	10.834 706	12.135 480	13.585 464	15.200 983	17.000 064	19.002 602

Compound Interest (Continued)

n	8.5%	9%	9.5%	10%	10.5%	11%	11.5%	12%	12.5%
26	8.340 137	9.399 158	10.586 858	11.918 177	13.409 705	15.079 865	16.949 096	19.040 072	21.377 927
27	9.049 049	10.245 082	11.592 610	13.109 994	14.817 724	16.738 650	18.898 243	21.324 881	24.050 168
28	9.818 218	11.167 140	12.693 908	14.420 994	16.373 585	18.579 901	21.071 540	23.883 866	27.056 438
29	10.652 766	12.172 182	13.899 829	15.863 093	18.092 812	20.623 691	23.494 768	26.749 930	30.438 493
30	11.558 252	13.267 678	15.220 313	17.449 402	19.992 557	22.892 297	26.196 666	29.959 922	34.243 305
31	12.540 703	14.461 770	16.666 242	19.194 342	22.091 775	25.410 449	29.209 282	33.555 113	38.523 718
32	13.606 663	15.763 329	18.249 535	21.113 777	24.411 412	28.205 599	32.568 350	37.581 726	43.339 183
33	14.763 229	17.182 028	19.983 241	23.225 154	26.974 610	31.308 214	36.313 710	42.091 533	48.756 581
34	16.018 104	18.728 411	21.881 649	25.547 670	29.806 944	34.752 118	40.489 787	47.142 517	54.851 153
35	17.379 642	20.413 968	23.960 406	28.102 437	32.936 673	38.574 851	45.146 112	52.799 620	61.707 547
36	18.856 912	22.251 225	26.236 644	30.912 681	36.395 024	42.818 085	50.337 915	59.135 574	69.420 991
37	20.459 750	24.253 835	28.729 126	34.003 949	40.216 501	47.528 074	56.126 776	66.231 843	78.098 615
38	22.198 828	26.436 680	31.458 393	37.404 343	44.439 234	52.756 162	62.581 355	74.179 664	87.860 942
39	24.085 729	28.815 982	34.446 940	41.144 778	49.105 354	58.559 340	69.778 211	83.081 224	98.843 559
40	26.133 016	31.409 420	37.719 399	45.259 256	54.261 416	65.000 867	77.802 705	93.050 970	111.199 004
41	28.354 322	34.236 268	41.302 742	49.785 181	59.958 864	72.150 963	86.750 016	104.217 087	125.098 880
42	30.764 439	37.317 532	45.226 503	54.763 699	66.254 545	80.087 569	96.726 268	116.723 137	140.736 240
43	33.379 417	40.676 110	49.523 020	60.240 069	73.211 272	88.897 201	107.849 788	130.729 914	158.328 270
44	36.216 667	44.336 960	54.227 707	66.264 076	80.898 456	98.675 893	120.252 514	146.417 503	178.119 303
45	39.295 084	48.327 286	59.379 340	72.890 484	89.392 794	109.530 242	134.081 553	163.987 604	200.384 216
46	42.635 166	52.676 742	65.020 377	80.179 532	98.779 037	121.578 568	149.500 932	183.666 116	225.432 243
47	46.259 155	57.417 649	71.197 313	88.197 485	109.150 836	134.952 211	166.693 539	205.706 050	253.611 274
48	50.191 183	62.585 237	77.961 057	97.017 234	120.611 674	149.796 954	185.863 296	230.930 776	285.312 683
49	54.457 434	68.217 908	85.367 358	106.718 957	133.275 900	166.274 619	207.237 575	258.037 669	320.976 768
50	59.086 316	74.357 520	93.477 257	117.390 853	147.269 869	184.564 827	231.069 896	289.002 190	361.098 864

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